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WEATHER MAP TYPING AND APPLICATIONS FOR ALBERTA

by

© PETER JOHN KOCIUBA

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research, for acceptance, a thesis entitled "Weather Map Typing and Applications for Alberta," submitted by Peter John Kociuba in partial fulfilment of the requirements for the degree of Master of Science in Meteorology.

DEDICATION

This thesis is dedicated to my

loving wife Mary Ann

and sons, John, Michael

and Gregory

ABSTRACT

This study gives a means of classifying synoptic pressure maps for Alberta using an objective correlation method initially developed by Lund. It also illustrates the development of a climatological or forecast aid, namely probabilities of precipitation. Classification of 500 mb. flows for the summer period, May to September, 1963-1971, has delineated 35 distinct flow patterns (Appendices 3 and 4). A year-round Alberta region surface map catalogue (33 distinct types, Appendices 1 and 2) was also developed using 26 years of data (January to December, 1946-1971). Both catalogues contain statistical information on map patterns for each month, so they are valuable climatological aids in themselves.

Probabilities of 24 hour summer precipitation (06Z-06Z, $\geq$ 0.01 inches) for 500 mb., surface, and combinations of these map types (May-September, 1963-1971) are calculated. They illustrate the application of the map type catalogues to precipitation forecasting. The results indicate that significant variations in precipitation probabilities are obtained for different map types or combinations of types.

The precipitation probabilities derived from the map catalogue data are verified for an independent data sample (06Z-06Z, May-September, 1972-1973) using the Brier score. The results indicate that the forecast probability nearly equals the observed frequency of measureable precipitation. However, little

improvement over climatology is obtained for many stations because there are too many forecasts near the climatological frequency of precipitation.

The derived probabilities are also used for verifications of the same period (May - September, 1972-1973) using 18Z-18Z precipitation amounts rather than 06Z-06Z. Comparable results are obtained.

The results using the precipitation probabilities are good considering that only two predictors, namely the 500 mb. and surface flows, are used.

Two final studies are made. The first consists of comparing maps for a winter period with the summer 500 mb. map catalogue. Indications are that the 500 mb. summer catalogue is useful in other seasons. The second study tests the ability of numerical weather prognoses to forecast the occurrence of the correct map type. Numerical prognoses forecast the occurrence of the actual map type about fifty percent of the time. With improved prognoses, the forecast verifications will undoubtedly increase.

The 500 mb. and surface map classifications should enhance our knowledge of synoptic pressure systems in Western Canada. The development of climatological and forecast aids for which the synoptic flow pattern is the dominant factor is greatly aided by map catalogues. The use of these map catalogues in a forecast office may prove to be very beneficial.

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INTRODUCTION

1.1 History

Out of the south cometh the whirlwind
And cold out of the north (Job 37:9).

Fair weather cometh out of the north
(Job 37:22).

When the east wind toucheth it,
it shall wither (Ezekiel 17:10).

Over the years man has tried to correlate weather variables. With the coming of surface maps and their patterns of highs and lows, other significant predictors of the weather evolved.

Winds to your back, storms (lows) on your
left (Buys Ballot's Law).

1.2 Synoptic Climatology

1.2.1 Background

During the Nineteenth Century, the relationship of wind to pressure systems greatly advanced synoptic-scale climatology and a new foundation was provided.

The classic approach to the study of surface patterns has been to investigate the effects of the surface airflow using six classes of isobars:

straight, anticyclonic or cyclonic curvature, anticyclone and cyclone centers and indeterminate situations. The emphasis of early classifications was on patterns that remain more or less recognizable for several days. When upper air data became more available, classifications were carried out for upper tropospheric patterns and the concept of large-scale "steering" of surface features was introduced.

Synoptic climatology developed considerably during and after the Second World War. Jacobs (1946) described the spatial distribution of certain meteorological elements for various air flows over Japan. He suggested that at that time the Weather Division of the Army Air Forces had better knowledge of weather processes over the Japanese Islands than did the Japanese themselves.

The large-scale approach through similarity of patterns for a period of days was developed about the same time,and is discussed by Elliot (1951).

Synoptic climatological studies were carried out for many parts of the world in the 1950's, and in the Soviet Union classifications for the entire hemispheric circulation were developed. In the late 1950's and 1960's objective means of classifying weather maps were devised. The methods and applications of synoptic climatology are well documented by Barry and Perry (1973) for this period.

Recently, considerable interest has been regenerated in weather classification schemes because of the availability of computers.

1.2.2 Classification Approaches

Various ways have been developed in which pressure maps or the weather elements themselves may be classified. Consider first an individual map of the pressure field (or contour field). The "static" pattern, may be classified into categories from two main standpoints: (i) the identification of individual features of circulation such as high and low pressure cells, ridges and troughs, in specified locations; (ii) the description of the complete pressure pattern, or its most significant features, by subjective or objective methods. The second approach covers an immense range of methods and is usually referred to as "map typing."

The pressure (or streamline) map may also be regarded in a "kinematic" framework, and two broad lines of work of comparable importance have been developed here. They are: (i) classification of cyclone and anticyclone paths, and (ii) the classification of circulation or air flow patterns. Examples of the kinematic approach are illustrated in the works of Elliot (1949, 1951) and the California Institute of Technology (1943). Inevitably,there is some overlap between these four methods in practice since the type of flow pattern is a function of the pressure distribution and its changes. The general aims of all approaches overlap and differences between them are essentially a matter of emphasis.

1.2.3 Pressure Pattern Classification (Map Typing)

Surface pressure pattern classification has been attempted since the turn of the century and is well documented by Barry and Perry (1973).

The subjective typing of pressure patterns presents several problems. Since atmospheric patterns are continuous, the delimitation between classes is somewhat arbitrary and therefore rather unsatisfactory. Another problem arises with limiting the number of map types. The decisions of any two meteorologists may well differ, so that a unique classification cannot be obtained.

Two further problems are often excluded from a map typing scheme. One is the variable intensity of pressure systems and the second is the seasonal variation in type characteristics.

Much thought has been given in recent years to numerical classification techniques. Three major approaches have been used - correlation methods, specification techniques and empirical orthogonal functions or eigenfunctions (Barry and Perry, 1973).

In this study, the correlation method is applied to the Alberta region based mainly on similar studies by Lund (1963) and Hartranft et al (1970a, 1970b). A complete description of this method is presented before Alberta results for 500 mb. and surface are given. Once the map types are obtained, they are used to illustrate the development of a climatological and forecast aid, i.e., probabilities of precipitation. Forecast verifications are included for independent data samples. A summary and conclusions are offered in the final chapter.

CHAPTER II

COMPUTERIZED MAP TYPING AND APPLICATIONS

2.1 Introduction

Recently, considerable interest has been regenerated in weather map typing schemes through the availability of computers. The map pattern classification technique developed by Lund (1963) is especially noteworthy since it is a practical and efficient means of objectively identifying recurring synoptic map configurations. The Lund technique demonstrates that by utilizing linear correlation methods, gridded or station data of certain meteorological parameters (e.g., sea level pressure, constant pressure heights, temperature, etc.) can be correlated to arrive at sets of similar configurations. This technique can be used either to classify a historical period of data into various surface or upper air weather types for subsequent climatological or forecast studies, or to determine specific map types associated with a particular weather phenomena. Because of the apparent potential of the Lund technique (Lund, 1963; Hartranft et al, 1970a), the Map Typing Project Office (12th Weather Squadron, Colorado Springs) has been applying the procedure, with extensive refinements and modifications, to develop a fully computerized system of classifying day to day map patterns.

2.2 Map Pattern Classification by Correlation Methods

2.2.1 Correlation Coefficients

The formula for the product moment linear correlation coefficient (r) for n pairs of values (in this context, n points on a map) is:

$$r_{XY} = \frac{\sum_{i=1}^{n} \{X_i - \bar{X}\}\{Y_i - \bar{Y}\}}{\left\{ \sum_{i=1}^{n} [X_i - \bar{X}]^2 \sum_{i=1}^{n} [Y_i - \bar{Y}]^2 \right\}^{1/2}} \qquad (1)$$

where the X_i are the n values for a given day and the Y_i are the n corresponding values for another day. The results of correlating each element of a map with all the other elements of a set of maps is a matrix of correlation coefficients with the diagonal values equal to 1.00 (each map correlates with itself 1.00). The lowest possible correlation coefficient is -1.00 (when two maps are completely opposite, i.e., highs are replaced by lows and vice versa).

The effect the above formula has on r when comparing various map patterns (isobars or contours) can be illustrated mathematically or by using specific examples. The theoretical derivation becomes tedious even for the simplest patterns, therefore specific examples computed by Scholefield (1973) will be discussed. In this paper, nine hypothetical weather maps were constructed, each being composed of isobars that were concentric about the center. Isobars were drawn at four millibar intervals for all maps and pressure values at twelve grid points were abstracted and computer correlations between all maps were made. The results obtained are summarized on the following page.

(i) Maps correlate perfectly with themselves at a linear correlation coefficient of 1.00.

(ii) Maps that have identical isobaric configurations, directions of flow and horizontal pressure gradients, will correlate at a value of 1.00 regardless of the pressure magnitudes, provided it is constant at any respective point. In other words, there would be no difference in the correlation coefficient between a low of central pressure 975 mb. or 1009 mb. as long as the pressure gradients are the same.

(iii) Maps that have identical isobaric configurations, directions of flow and different but constant horizontal pressure gradients, correlate identically.

(iv) Maps that have identical isobaric configurations, direction of flow and different but variable horizontal pressure gradients do not correlate identically but are still very similar. The degree of similarity between such maps decreases with the degree of gradient variability.

(v) Maps that have identical isobaric configurations and horizontal pressure gradients but completely opposite flow patterns correlate with each other at - 1.00 and are therefore completely opposite, i.e. a high in the center compared to a low.

Considerable insight into how the linear correlation coefficient equation works, when used to correlate surface weather map patterns, is given from the above study. The examples used show that the degree of correlation between maps is almost entirely dependent upon the isobaric configurations and the directions of flow of the maps being correlated. Various horizontal pressure gradients have no effect on the correlation as long as the

gradients on each map are constant. If they are variable, that is, stronger on some portion of the map than on others, the correlation between them will be reduced.

This means that if a large number of maps is being correlated to arrive at a set of similar map types, each map type subset will be composed of maps with similar isobaric configurations and directions of flow. It will, however, be quite possible and very likely that maps of a similar type will have widely different horizontal pressure gradients. Because the gradient is closely related to the intensity of a pressure system, it becomes significant when one tries to associate certain weather conditions with map types. Therefore, as a second approximation, further consideration should be given to typing maps according to the pressure gradient strength in an effort to increase the degree of association between map types and various weather conditions.

2.2.2 Threshold Correlation Coefficient

Once all maps are correlated with each other, there are a number of ways to analyze the data and select types. Type selection depends upon the choice of a threshold value of the correlation coefficient which is used to divide the sample of maps into groups having a degree of similarity in pattern. The question arises: At what level of correlation does the similarity between pressure patterns cease? It has been found that if the value is too low, the data sample will be divided into fewer map types, containing a large number of maps in each type. The map types would be rather general and there would be wide variations in the detailed circulation patterns within each type. With each

increase in the threshold value of the correlation coefficient, there is an accompanying increase in the number of types generated. This is because each map type would contain maps with a higher degree of similarity and therefore it requires more types to depict the range and orientations of map patterns which occur over the area of interest. More significantly, an increase in the threshold correlation coefficient yields a large increase in the number of uncorrelated cases, i.e., the number of maps which do not correlate with any type.

Lund (1963) and Bjorem (1966) used 0.70 as a threshold in their surface map typing procedure; for upper air patterns, Augulis (1969, 1970a, 1970b, 1970c) used 0.80. The Map Typing Project Office experimented with several different threshold values (0.70, 0.80, 0.90). The practical value for typing upper air maps was found to be 0.90, while a value of 0.70 was the optimum for typing surface maps (Hartranft, 1970a). Later tests and experience in surface map typing, indicated that 0.80 was the practical threshold value (Nieman and Sabin, 1972). The results were based on the geographical size of the area, similarity of weather for stations within the area and similarity of maps within each map type.

There is still no overall consensus on the choice of a threshold correlation coefficient. Proponents of the high correlation coefficient (e.g. 0.90) want better discrimination for the relatively rare events. Conversely, the main argument for a lower correlation coefficient (e.g. 0.70) is to limit the total number of map types to include more cases in each type and increase the reliability of the climatological statistics generated for each type.

Some authors have suggested the use of two thresholds in

determining types. One is to use a high value to derive the types initially and then use a lower threshold to assign cases to the types. Another method is to use a high threshold initially, then those cases which remain uncorrelated would be correlated at a lower threshold to obtain additional types. This would result in two types of classification - strong and weak.

The selection of a threshold value of the correlation coefficient, therefore, requires careful consideration since this is the control on how similar the map patterns included in a given type must be. The choice will depend upon the map size being used, upon the type of data field being correlated and upon the kind of climatological guide being developed.

2.2.3 Map Typing Area (Windows)

Lund (1963) selected a window which included surface pressure data for twenty-two irregularly spaced reporting stations in the northeastern United States, map size area approximately ten degrees latitude by thirteen degrees longitude. Bjorem (1966) used different windows for his surface and 500 mb. map types in the northwestern United States. Bjorem's surface map type area included data from nineteen irregularly spaced reporting stations, approximately ten degrees of latitude by thirteen degrees longitude, while his 500 mb. map types used seventeen grid points from a data grid, approximately fifteen degrees latitude by fifteen degrees longitude.

Augulis (1969, 1970a, 1970b, 1970c), used gridded data for 500 mb. from the National Meteorological Center (NMC) octagonal grid as the data base and included fifty-two data grid points, approximately thirty

degrees latitude by fifty degrees longitude. This large map size was selected to emphasize large-scale flow features, i.e., long-wave and jet stream positions. Minor features such as migratory short-wave troughs and ridges were weighed lightly in their precipitation climatology studies. It should be noted, however, that excessive map area sizes introduce some interpretation problems when attempting to apply the map types. Small-scale features of the circulation will affect only a relatively small number of data points within the network and consequently will have a negligible effect on the overall correlation. Therefore, one would expect to find two maps which are highly correlated but which are highly dissimilar in one or more portions of the network.

Initial work at the Map Typing Project Office in Colorado used gridded data of surface and 700 mb. comprising six NMC diamond shaped grid points, with an additional six grid points obtained by interpolation (twelve points in all). The map size covered an area with dimensions of ten degrees of latitude and fifteen degrees of longitude. In more recent work, map catalogues were produced for selected areas or "windows" in the U.S.A. These windows included from nineteen to twenty-four NMC grid points spaced at 381 kilometers.

From the above discussion, it can be seen that the selection of the map size or "window" for a given data network is a subjective consideration which is probably best resolved by experimentation. There are, however, important factors to be considered when determining the optimum map typing area, and these are summarized below:

(i) Grid or data spacing - Area must have a sufficient number of data points to adequately distinguish the flow.

(ii) Problem to be solved - Size of area depends on whether the problem is global, synoptic or mesoscale.

(iii) Size of correlation coefficient - If a large correlation coefficient plus a small number of types is desired, a small area must be used. These three factors are inter-related.

(iv) Persistence - Grid size must be small enough so that a map type does not persist for too long a period. Changes in pattern, not persistence, are preferred, at least in zonal westerlies studies.

(v) Computer limitations - The computer programs and computer may be limited as to the number of data points and the area used.

(vi) Period of Forecast - Area should be sufficiently large to describe the flow pattern that will govern the weather during the forecast period.

2.2.4 Basic Analysis Technique

Each map describing the synoptic pattern is correlated with all other maps in the data sample using equation 1. A count is made among all the maps to determine how many maps correlate at the threshold correlation coefficient or greater with each map in the sample.

After counting maps, a choice has to be made in selecting "typical" weather map types. The method described by Lund (1963) and adopted by the Map Typing Project Office is to determine the map which has the largest number of other maps correlating with it at or above the threshold value and designating it Type 1. Following the Lund method, the next step is to remove from the sample all of the maps initially assigned to and including Type 1.

The counting procedure is then applied to the remaining maps and the procedure repeated. This counting-selection-elimination procedure is repeated creating Types 2, 3, 4, etc. until only a few maps remain. It is apparent that the object of this procedure is to identify map types which are mutually exclusive, i.e., where one type does not correlate highly with another type.

Generally there is a cut-off value preset below which no further types will be chosen. This cut-off value is essentially arbitrary and varies from author to author. Lund (1963) terminated selection of types when he had selected ten types. Hartranft et al (1970a) terminated the selection and assignment when the number of maps in the sample fell below two percent of the original sample or when ten map types had been selected - whichever occurred first. Later work by the Map Typing Project Office in producing surface map catalogues terminated selection of types when the number of maps remaining to be typed fell below two percent of the original sample or when thirty map types had been selected - whichever occurred first.

Maps are assigned to a selected weather type on the basis of the correlation coefficient being equal to or above the threshold value. In the initial assignment, no distinction is made concerning how much greater than the threshold value a map correlated with a given type. It is often found that one map may correlate above the threshold value with two or more types. However, during the initial analysis, the map is assigned to that weather type with which it first correlates with a coefficient equal to or greater than the threshold value. It is then eliminated from eligibility into later created types.

Once the weather types are chosen and all maps are assigned

to a type (or to an uncorrelated "residual" group), the maps are recorrelated against the selected types to determine which type each map correlates with most highly. This reassignment step is significant in that it not only assigns a map to the type it most resembles, but also identifies map types which initially had a low frequency of occurrence, and after the reassignment phase, become major types.

There are minor variations to this procedure. If one map correlated above the threshold with two or more map types, some investigators would assign it to both types in an attempt to increase the data base for climatological studies. However, a problem arises in applying the results of the classification scheme to an objective forecast study. A map may correlate above the threshold value with two weather types and the pressure pattern differences may be small. Yet the objective forecast method applied to the map in consideration to determine the probability of occurrence of some weather phenomena may be entirely different.

If the number of duplicated classifications with more than one type are numerous it may be advantageous to define "hybrid" groups. These hybrid groups would increase the number of types but may be associated with significantly different weather phenomenon than the two types considered separately. The map type assignment will depend upon the type of forecast or climatological aid being developed.

2.3 Applications of Objective Pattern Classifications

2.3.1 Case Studies of Special Weather Phenomena

The primary purpose of this application is to identify recurring synoptic patterns or map types which occur before or during troublesome and hazardous weather phenomena. Special map type files can be prepared of surface and upper air maps associated with these critical weather situations and can be used as a valuable guide in diagnosing the current situation, interpreting prognostic charts and alerting forecasters to potentially dangerous synoptic situations. This particular concept is not new. The value of preparing case studies on critical weather phenomena has been publicized in meteorological literature for many years. Examples which have been prepared for Alberta are provided by Thompson (1950), Burns (1970), Storr (1953) and Hage (1957). This approach is commonly referred to as the case study method of investigating forecast problems.

In developing a case study, weather maps are collected in one of two ways. One method involves the accumulation of surface and upper air maps on an "as-you-go" basis, in which maps and data are collected and filed each time a particular weather event occurs. The second method involves a search of historical weather records for days and time periods in which a particular weather event occurred. The associated weather maps for these occurrences are then obtained from historical weather map files.

Attempts are then made to establish common relationships between certain circulation parameters and patterns and the weather event. It is difficult to identify objectively certain recurring patterns or map types. This is an area where computer map typing procedures play a significant role, not only

from the standpoint of saving a considerable amount of time, but primarily because they yield more objective and reliable results.

Even if certain map types are identified subjectively, the problem that still arises is that the selected types suggest only the necessary conditions. Further testing, referred to as the "negative check," is required to screen the entire weather map file and select all similar weather types which conceivably could produce the weather phenomenon. The negative check must be applied impartially to all situations. If the check is valid, only a small number of similar map types will be found where the phenomenon did not occur. The negative check will therefore reveal whether some additional screening must be devised. Since this phase of case studies is extremely tedious and time consuming, computerized map typing procedures can play a significant role.

2.3.2 Objective Map Typing for Case Studies

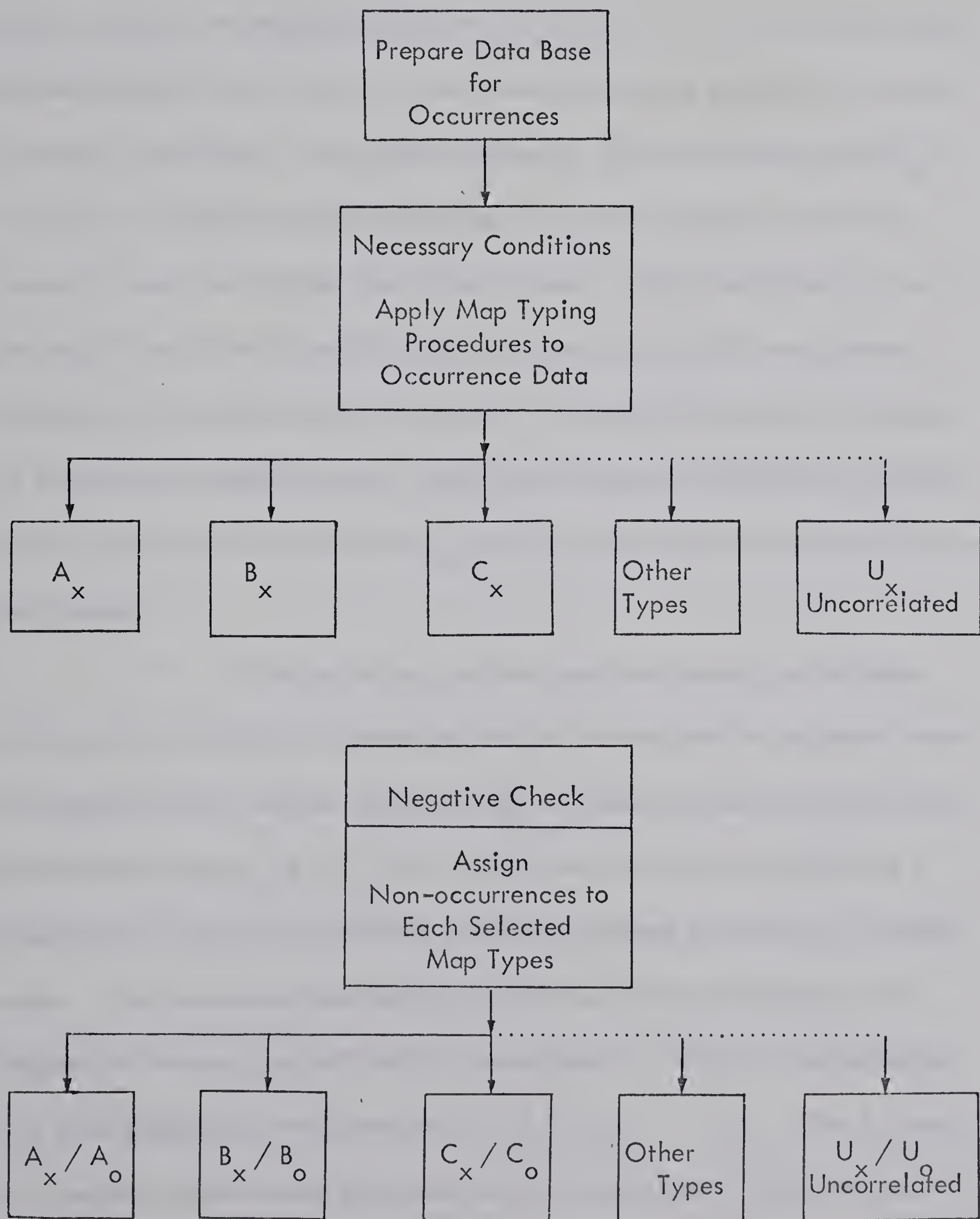
The general approach as used by the Twelfth Weather Squadron for developing case studies is illustrated in Figure 1. The main weakness of the method is that a separate data base must be compiled, and map types generated, for each different weather phenomenon to be investigated.

The first step is to obtain a listing of the occurrence data for the selected weather event. This includes the data and the period of the day for each occurrence, and any other pertinent information. The occurrence data base should be as large as possible to ensure reliable results.

FIGURE 1

General Case Study Approach for a Special Weather Phenomenon

(from Hartranft et al, 1970a, p. 18)



The map typing procedure described in Section 2.2 is applied to the event occurrence data using the appropriate synoptic data. The choice of map data depends on the type of case study being developed. The pertinent map data are correlated for the occurrence dates in order to identify the map types (viz., A_x, B_x, C_x, . . .). Those maps which are not assigned to any type, i.e., correlated less than or equal to the threshold correlation coefficient , are grouped together in 'an uncorrelated' group (U_x). The degree to which the selected map types represent necessary conditions is inversely proportional to the size of the U_x group. If the size of the U_x group is too large it means that there is too large a variety of dissimilar map patterns, representing the weather event in question. The circulation pattern is probably an insignificant causative factor. Based upon experience gained by the Twelfth Weather Squadron, the size of the U_x group should not exceed ten percent of the total sample.

Whether or not a reliable positive forecast can be issued during positive situations is determined only by the results of the negative check. The negative check involves correlating <u>all</u> the remaining data with each of the selected map types A_x, B_x, C_x, etc. Each non-occurrence is assigned to a selected map type if the correlation coefficient exceeds or equals the threshold value. If the non-occurrence correlates with more than one map type, it is assigned to that map type with which it correlates mc t highly. This procedure will yield groups of non-occurrences, A_o, B_o, C_o, . . . U_o. The A_o group, for example, would contain the sample of non-occurrences in which the map pattern was similar to the occurrence map type, A_x. The relative frequency of

occurrences to non-occurrences of an event for a given map type will determine whether additional screening procedures are required. If the relative frequency is low, this is the case and other parameters such as moisture, stability, temperature, or history should be investigated.

A study of snowfall using this approach is seen in Hartranft et al (1970a, 1970b).

2.3.3 Area Map Type Catalogues

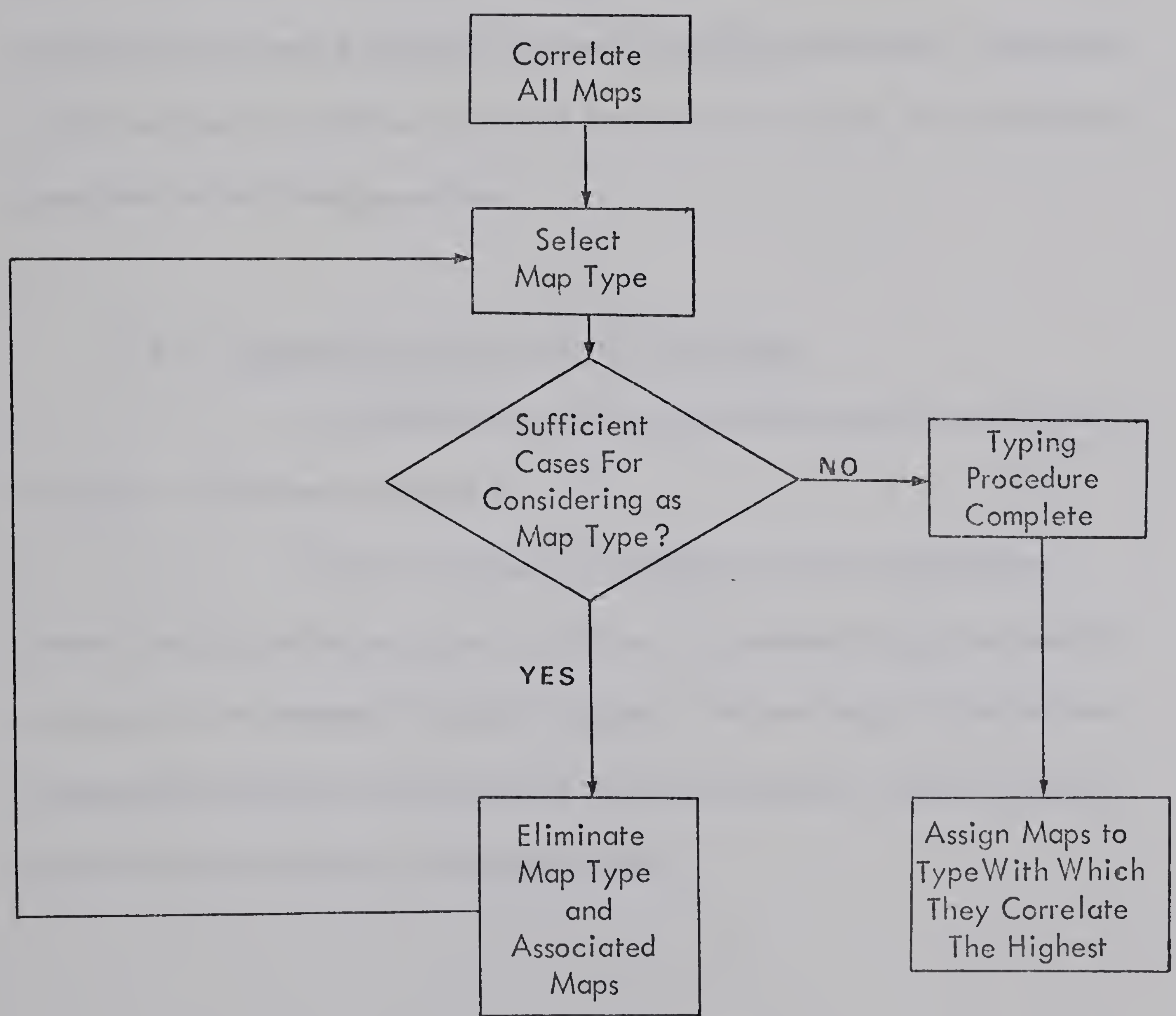
A second approach toward applying the weather map classification scheme is to generate map types using a full data sample. A major weakness of this method when used in the initial step of a forecast study is the lack of control in choosing map types. There will be in all probability no specific map type which will enable a reliable occurrence or non-occurrence forecast to be made. As a result, greater stratification of data is required. The primary advantage is that a catalogue of map types can be generated for a particular geographical area, and this catalogue used to study a variety of weather phenomena. This would eliminate the need to apply map typing procedures to separate sets of data when investigating different weather phenomena. Since the entire data sample is used no negative check is required.

The series of steps which must be followed to obtain representative map types for a particular area is illustrated in Figure 2 and has been explained in Section 2.2.

FIGURE 2

Procedure for Determining Map Types for Area Map Type Catalogue

(from Nieman and Sabin, 1972, p. 3)



The typing procedure is straightforward but a problem arises when the number of maps becomes large, i.e., the excessive number of correlations required initially. The correlation matrix is a symmetric matrix about the principal diagonal (diagonal elements are all 1.00). As a result, $n(n-1)/2$ correlations are required for a data sample of n maps. For one year of data (one map per day), this entails approximately 66,430 correlations whereas for ten years of data, this requires 6,666,726 correlations! Techniques which correlate the minimum amount of map data are required, two of which are described in the following sections.

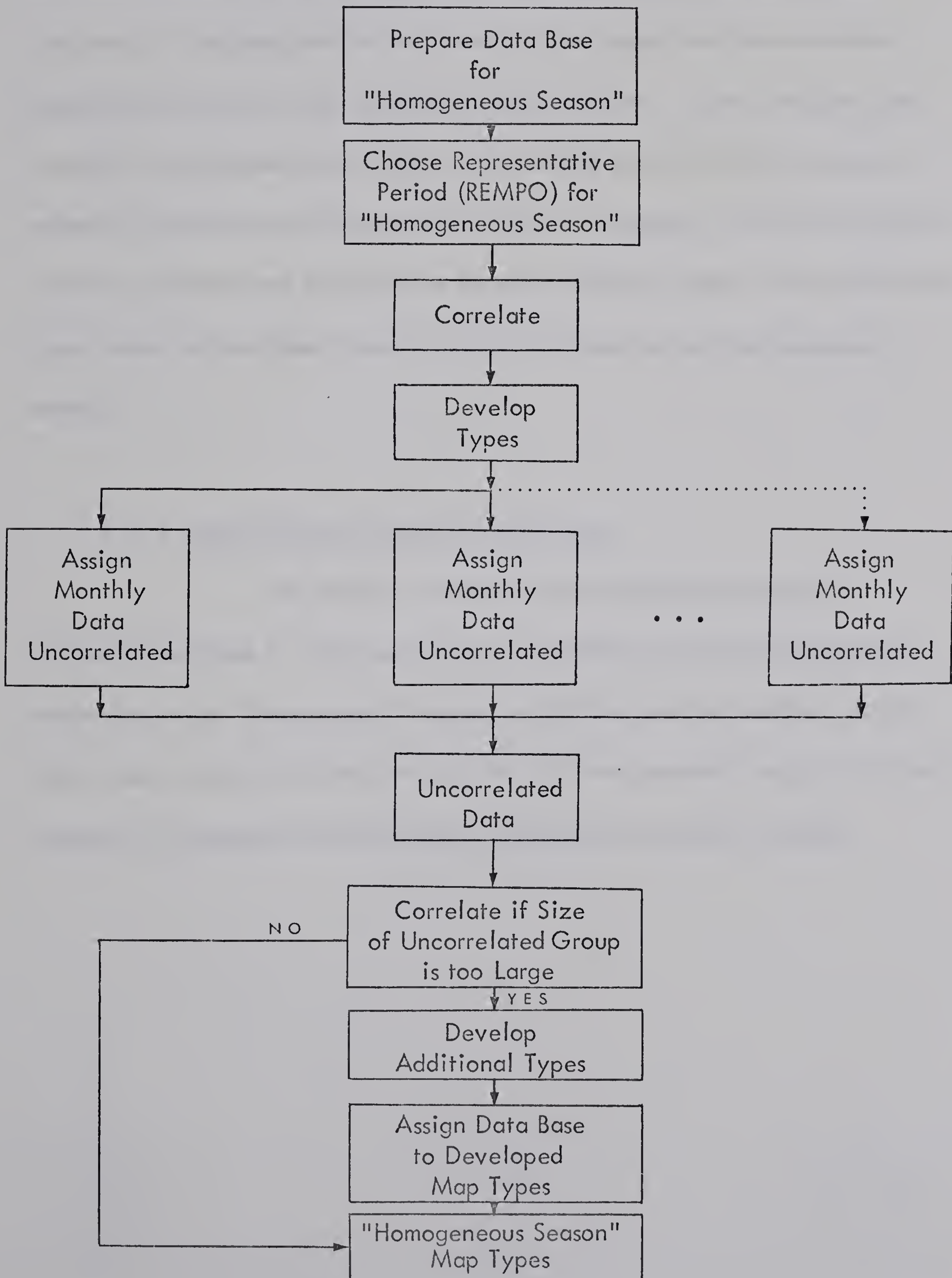
2.3.4 Representative Month (REMPO) Technique

The REMPO technique for developing seasonal catalogues of map types is illustrated in Figure 3.

First it is necessary to decide upon the "homogeneous seasons" for the particular region in question. The seasons will not necessarily correspond to the standard "calendar" seasons. The next step is to determine a representative month (or similar period) within each season. Both of the above should be determined from climatological data.

FIGURE 3

Representative Month Technique (REMPO) to Develop Seasonal Map Type Catalogue



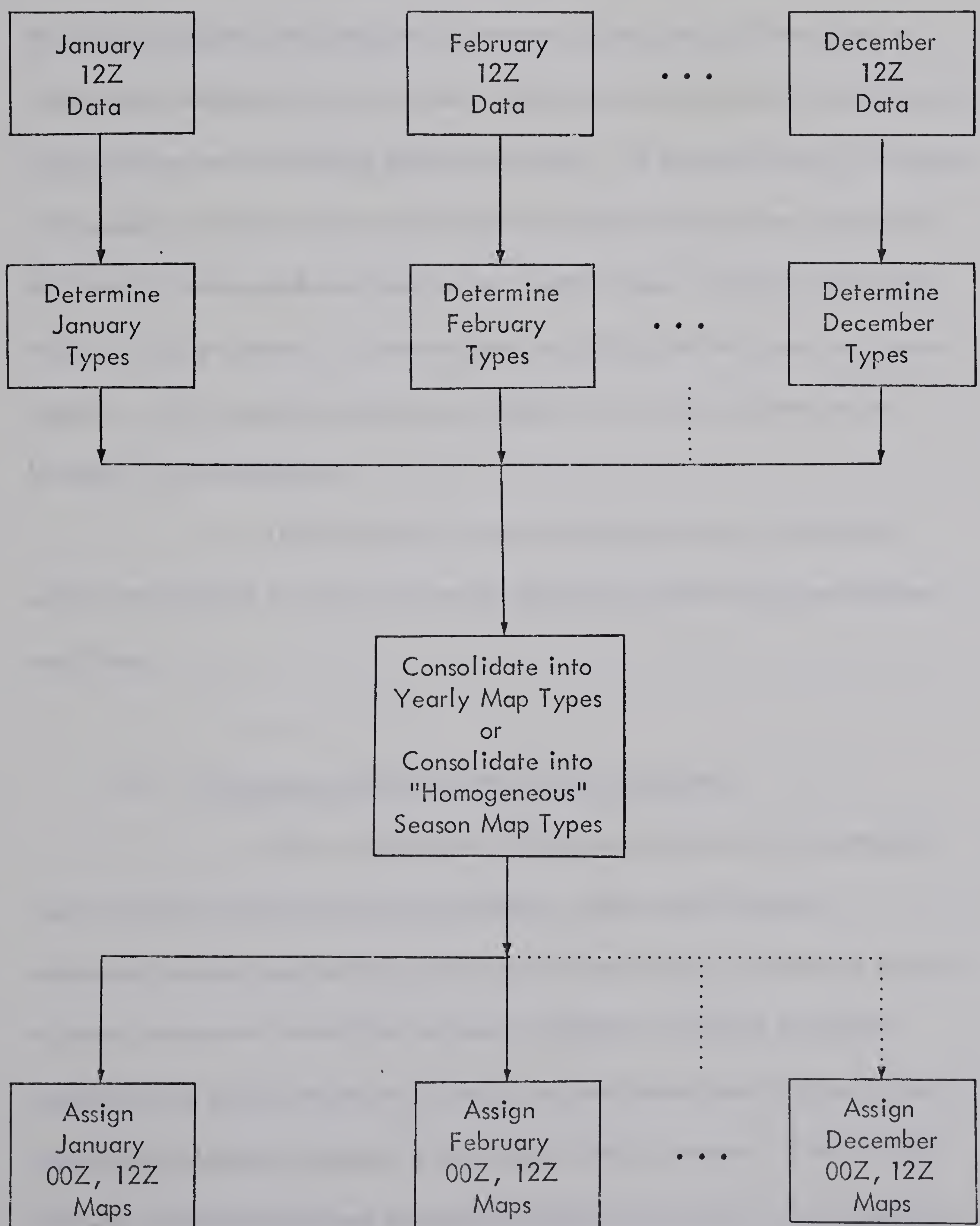
The actual procedure can be followed by referring to Figure 3. Data for each day in the representative period (several years of data) are correlated against all other days, and map types are developed as discussed previously. Complete data for each month of the season are then correlated against the types and a type assigned to each map time. If after this step the number of uncorrelated maps is high, it is possible that the initial types do not adequately describe the "homogeneous" season. Therefore, all the uncorrelated data are assembled and correlated to develop additional types. These additional types added to the original types provides map types for the "homogeneous" season.

2.3.5 Batch Processing (BATCH) Technique

The BATCH technique for developing map types is illustrated in Figure 4. This method may be applied to develop types for the entire year or for "homogeneous" seasons as with the previous method. In the latter case, since all the data are used for the "homogeneous" seasons, it is not necessary to determine a climatological representative month or months.

FIGURE 4

Batch Processing Method Used to Develop a Map Type Catalogue



Map types are developed independently for each month. Many of the types from one month to another will be similar to each other since they were developed independently. Therefore, in order to decrease the total number of types, it is necessary to combine types. This can be done by grouping the types developed into homogeneous seasons or, considering all the data, a yearly map catalogue can be obtained. Either procedure is done by grouping the types together and correlating against each other. In developing the final types, a threshold correlation value must be applied which is higher than or equal to the threshold value used to determine the monthly types. By using a threshold value of 0.80 or greater, this ensures that only highly similar types are grouped together. All uncorrelated cases are considered to be unique types and are included in the final types.

The final phase is to recorrelate each map in the data sample and assign it to a map type on the basis of the value of the correlation coefficient.

2.3.6 Comparison of REMPO and BATCH Techniques

Sabin and Nieman (1972) have compared the two methods used to produce synoptic map type catalogues. They found that both techniques produce approximately the same number of types. However, there is no exact one-to-one correlation between a REMPO and BATCH map type. Because of the typing procedure, it would be pure coincidence if a particular map date was found to represent a map type in both catalogues. Nevertheless, there are similarities between the two sets which can be seen in the frequency

of occurrences, the pressure regimes depicted and the actual correlation of types in the two sets.

Since the two methods produce comparable map type sets, the choice of which method to use is primarily a matter of computer time and storage. The computer running time is nearly equal for REMPO and BATCH. Since 1972, all Twelfth Weather Squadron map typing projects use the BATCH processing method. The decision was based on the fact that BATCH is much more straightforward, requires less manual manipulation of data, and considers data for the entire period rather than data for only a representative month.

2.4 Disadvantages of Correlation Methods

Objections to map pattern classification using correlation methods are sometimes raised. Clearly the procedure to produce types are not entirely free of subjectivity. Factors which affect the computational problems such as the threshold correlation coefficient, area size and the number of data points have been covered in previous sections.

In the assignment of days to the catalogue types, some misclassification may occur because a map may correlate above the threshold value with more than one type. The usual procedure, is to place those situations in the group for which the correlation coefficient with the 'pattern day' is a maximum but it may be preferable to define 'hybrid' groups, if duplicated classifications are numerous. The decision of defining 'hybrid' types or not will depend on the weather phenomenon to be investigated.

Most important of all, it must be recognized that the correlation

method relates each day of a given group to the 'pattern day' and does not consider the pressure magnitudes or correlations within members of the group. This clustering method may not produce the optimum grouping of the data.

It may be instructive to determine the mean pressure field for each group, although the features on this are weaker than those on the corresponding pattern day. The choice depends on the time scale involved and the type of study being undertaken. It should be stressed that in the case study approach a single 'key' map should be used rather than a mean map to represent the map type. If a mean map was used, many days would not correlate with the mean map. A mean map may be preferable if one is looking for large-scale circulation features or trying to minimize variations between maps within a type to facilitate visual typing.

From a statistical point of view, two major questions concern the effects of spatial and temporal autocorrelation and of non-linearity. The product-moment correlation coefficient (equation 1) theoretically assumes that the data used in its calculation are not serially correlated, i.e., there is no correlation between $X_{i,t}$ and $X_{i+k,t+m}$ $(k, m = 1, 2, \ldots)$. The fact that one is spatially and temporally sampling a continuous field variable (pressure or height) puts the validity of this assumption in jeopardy. Caution must, therefore, be used in interpreting such correlations, certainly in terms of their significance level. The second difficulty is that fields of pressure or geopotential height are generally non-linear and considerable information may therefore be lost in correlating fields on the basis of a linear technique.

On the whole, the advantages of using linear correlation methods far outweigh the disadvantages. The development of synoptic climatological aids based upon map types allows an integration of local area climatology into each forecast.

CHAPTER III

SURFACE MAP CATALOGUE FOR ALBERTA

3.1 Introduction

The Map Typing Project Office (Twelfth Weather Squadron, United States Air Force, Colorado Springs) has, since 1968, been conducting applied research into the field of computer derived weather map types. In 1972, this office began the production of surface pressure map catalogues for fourteen regions (windows) in the United States. A surface map catalogue has been produced by the above office for Alberta which will be described in detail in the following sections.

3.2 Data and Area Used for the Alberta Window

The data used in the preparation of the map type catalogues were obtained from the Fleet Numerical Weather Central (FNWC), Monterey, California and consists of grid point mean sea level surface pressure data (standard grid spacing of 381 kilometers) for an eighteen by seventeen point grid covering the United States and most of Canada. The total period of record was January to December 1946 - 1971. The pressure data at the 12Z (Greenwich Mean Time) reporting time are available for each grid point for the entire period while values for the 00Z times are available only from 1955-1959 and 1962-1971.

The area covered by the Alberta surface map catalogue is illustrated in Figure 6, Appendix 1. Ideally, the area in which one is interested should be centered in the window. This was not possible for the Alberta window because of data availability. Since most weather systems which affect Alberta originate in the Pacific, it was decided to include more data gridpoints in the west rather than the east. The uppermost boundary of available gridpoint data coincides with the upper boundary of the window (grid points one, two, three). The computer program used by the Map Typing Project Office allows a maximum of twenty-four grid points in the production of a catalogue. Once derived, the map types apply to all locations which fall within the window but it has been found that the similarity of maps within a type generally extends far beyond the area used to determine the type for windows of the size used.

3.3 Analysis Procedure

The analysis procedure follows the BATCH processing method (section 2.3.5) with some modifications because of the large amount of data. The initial phase in the selection of map types involves the computation of correlation coefficients of each map with all other maps for a given month. The initial correlations are carried out using 12Z map data for the period 1954-1971. As the coefficients are determined the number of correlations that equal or exceed 0.70, 0.80 and 0.90 are tabulated.

The next phase involves the determination of map types for each month in the following manner (for a more detailed description, see Chapter II):

(i) The map that correlates with the greatest number of other maps for a given month, with a correlation coefficient of 0.80 or higher, i.e., threshold value 0.80 , is selected as a map type. If two or more maps have the same number of correlations equal to or above the threshold value, the most recent map is selected as the type.

(ii) All maps that correlate with the selected key map with a coefficient of 0.80 or higher are eliminated from further consideration.

(iii) Steps (i) and (ii) are repeated until either the number of types reaches a predetermined maximum (usually 30), or the number assigned to a type is less than a predetermined minimum (usually six).

(iv) Once the map types are selected, each map for that month is assigned to the map type with which its correlation is the highest. However, if its highest correlation does not equal or exceed 0.80, no assignment is made.

(v) Any map type having fewer than two percent of the total number of maps for that month assigned, is eliminated as a map type. The dates and grid point pressure values for each type (key map) are stored for further processing.

The data are processed one month at a time, i.e., all maps occurring in January for the period of 1954-1971 are processed first, then February, March, etc. Two reasons for processing the data in this manner are computer core availability and data storage in monthly increments.

Once the map types are determined for each of the twelve months, the correlation of each monthly map type with all other monthly types is done. This determines the final map types for the area by consolidating similar types.

The final types are determined in the following manner:

(i) The monthly map type that correlates with the greatest number of other map types ($\geq$ 0.80) is selected as a final map type. Again, the most current monthly type is selected if two or more monthly types have the same number of correlations.

(ii) All monthly map types that correlate with the selected type with a coefficient of 0.80 or higher are eliminated from further consideration.

(iii) Steps (i) and (ii) are repeated unless the number of final types reaches a predetermined maximum (usually 40).

(iv) All monthly map types that have not been assigned to a final type are considered unique and are designated as final map types unless the number of types exceeds forty.

(v) The above procedure yields a map catalogue of recurring synoptic patterns for the entire year. Once the final types are determined, each map in the data period (1946-1971) is assigned to the map type with which it correlates the highest (primary type), provided the correlation coefficient is greater than or equal to 0.80. If this is not the case, the map is assigned to the uncorrelated (U) group.

(vi) The second highest correlation coefficient is also computed for each map, and if it exceeds the threshold value, the map type associated with that coefficient is recorded (secondary map type). 'n addition, if the second highest correlation coefficient is within 0.05 of the first, as well as being equal to or greater than 0.80 , the occurrence of a secondary highly similar type is noted.

3.4 Further Processing by Colorado Springs

Once the assignment is complete, a tabulation of map type occurrences and frequency, information on types most frequently following a given type, and information on persistence of each type is performed. The characteristics of the types are stratified for each month, providing very useful information on the behaviour of synoptic systems.

3.5 Results for the Alberta Surface Map Catalogue

In the production of the map types for Alberta, a total of 6,579 maps was used in the initial correlations and 14,554 maps were assigned to the final map types. The catalogue, run on a mini-computer system, required approximately ten hours of computer processing time, which is about equally divided between the central processing procedure and the input/output section.

3.5.1 Monthly Surface Types

Table 1 illustrates the results obtained for each month when the 12Z maps were processed for the period 1954-1971. Due to an error in a data date, 1953 data for July were also processed giving 585 days (maximum was to be 558). This data error has no effect on the final generation of the map types since no key map was selected from the 1953 data. It is interesting to note that the average number of map types for each month is eighteen and that this remains relatively constant throughout the year. The number of uncorrelated maps averages twenty-four percent but a noticeable difference can be observed.

TABLE 1

Surface Map Types for Alberta for Each Month and the Final Yearly Totals

MONTH	NUMBER OF DAYS	NUMBER OF MAP TYPES	NUMBER OF UNCORRELATED MAPS (MONTHLY PERCENTAGE)
January	558	19	126 (23)
February	508	17	110 (22)
March	554	15	148 (27)
April	538	17	147 (27)
May	557	21	137 (25)
June	538	19	157 (29)
July	585	18	161 (28)
August	558	20	142 (25)
September	540	18	149 (28)
October	548	16	95 (17)
November	539	19	103 (19)
December	556	18	122 (22)
TOTALS 1954-1971	6,579	217	1,597 (24)
FINAL CATALOGUE 1946-1971	14,554	33	3,836 (26)

The maximum number of uncorrelated days occurs during the summer period, with a minimum during the October – December period. This is probably the result of stronger thermal gradients in the late fall and early winter, compared with the summer. The same results are evident for the uncorrelated group, Appendix 2.

3.5.2 Yearly Surface Map Types

The map types for each month (total 217) have been consolidated into a catalogue for the year comprising thirty-three map types. These types account for seventy-four percent of the days in the development sample when each map time is correlated with the key pattern of the thirty-three types.

In the development of the surface types, Map Type 1 was the most predominant recurring pattern of the monthly types; Map Type 2, the second and so on.

However, when the reassignment of each date in the period of record was completed, Map Type 4 became representative of the most days, i.e., the most predominant excluding the uncorrelated group, then Map Type 2, etc.

3.5.3 Display of Surface Types and Characteristics

Appendix 2 contains the characteristics of each map type and the associated key map pattern. The map type most frequently following and the most frequent duration statistics are computed for the types when data dates are separated by a twelve-hour period (recall that all 00Z maps were not available).

In all cases, the statistics are stratified by month and show the seasonal characteristics in the map types. For example, Map Type 1 is predominantly a winter phenomenon, occurring infrequently in the summer. This type is characteristic of a cold outbreak of Arctic air. The opposite is true for (predominantly a summer and fall map). This type results because the strongest thermal gradient is shifted northward at this time of the year.

Other characteristics can best be explained by referring to Map Type 1, Appendix 2. The statistics on the map type most frequently following in the next twelve hours is tabulated for all map types but only the five most frequent are listed. For Map Type 1 in January, Map Type 1 will follow itself in the next twelve hours, forty-seven percent of the time. Other map types which have been found to follow are: Map Types 27 (16%), 16 (8%), uncorrelated U (8%) and 30 (5%).

In the persistence statistics, all consecutive twelve-hour occurrences of the same map type are tabulated and frequencies computed. The four most frequent durations are listed under this heading. Referring to Map Type 1 in January, fifty-three percent of the maps processed occurred for a single twelve-hour period, twenty-three percent for two twelve-hour periods, thirteen percent for four and nine percent for three. The map type statistics for following types and persistence show the seasonal migration of pressure systems.

3.6 Highly Similar Surface Map Types

The selection of map types was carried out such that no two types correlate above or equal to the threshold correlation value with one another.

Intercorrelation of the surface map types have confirmed this hypothesis. This procedure also provides a means of checking the selection of the map types.

Map Type 2 and 17 illustrate the problems in visual typing. The correlation between these two types is below the threshold value of 0.80 but when the correlation is output by the computer, round-off produces a value of 0.80. Inspection of the key patterns show that the maps are indeed similar, the difference being related to the intensity of the system and the variation in one area of the window. The flow pattern over Alberta, however, is definitely similar.

In order to obtain more information on these two map types, a comparison of the primary and secondary correlations for each date in the period May to September 1963-1971 was made. This time period was chosen since the 500 mb. map catalogue and the precipitation probabilities described in other chapters used the same time period. The comparison indicated that the pattern occurred more frequently than Map Type 17. It was also found that when the primary map type for a date was Type 2, the secondary was frequently Type 17. The reverse, however, never occurred, i.e., primary Type 17, secondary Type 2.

3.7 Highly Uncorrelated Maps

Another aspect of the intercorrelations which were computed, was the highly uncorrelated maps, i.e., more specifically the correlations less than or equal to -0.80. This implies that the maps are similar but have reversed flow directions. Table 2 indicates the map types which correlate with each other less than or equal to the negative of the threshold value.

TABLE 2

Intercorrelation of Surface Map Types.

Coefficients Less Than or Equal -0.800.

MAP TYPE	MAP TYPE	CORRELATION COEFFICIENT
1	2	- 0.956
1	9	- 0.846
1	17	- 0.831
2	10	- 0.827
3	6	- 0.822
3	30	- 0.847
4	5	- 0.844
4	27	- 0.863
6	12	- 0.871
6	15	- 0.828
7	10	- 0.895
8	14	- 0.837
17	23	- 0.897
30	33	- 0.814

Visual inspection of the key pattern maps show that the flow directions are completely reversed for those types indicated in Table 2. The best example is Map Types 1 and 2, which show that the locations of the high and low pressure areas are essentially interchanged.

CHAPTER IV

SUMMER 500 MB. MAP CATALOGUE

4.1 Introduction

A summer 500 mb. map catalogue of recurring map patterns was produced. This catalogue, when used in conjunction with the surface map catalogue, will reveal information concerning the three-dimensional nature of synoptic pressure systems. The following sections describe the data, areal size and the analysis procedure used for the generation of this catalogue.

4.2 500 mb. Summer Map Catalogue

4.2.1 Data and Areal Size

Height data for 500 mb. was abstracted for twenty rawinsonde stations in Western Canada and the Northwestern United States using Monthly Upper Air Summaries and analyzed maps from the Edmonton Weather Office. The data period covered was May to September 1963-1971 (2,754 maps, 00Z and 12Z). Figure 7, Appendix 3, illustrates the stations used in the final catalogue.

Initial data abstraction included ship 4YP but after some preliminary computations were rejected since great variation could occur in maps between 4YP and the coast of British Columbia. A large area was

purposely chosen since the location of certain weather systems are known to change dramatically in a twelve-hour period (Hage, 1957).

In order to obtain a complete data base for the period chosen, values were interpolated from analyzed charts if they were missing for any reason. This was also the case for stations which had been relocated at some time during the period of record, i.e., values were interpolated at the present (1973) locations (UIL, XD). The Vernon rawinsonde (VK) was not operational until the fall of 1971 so values were interpolated from analyzed charts for the entire period 1963-1971. This makes the catalogue compatible with the present day reporting locations.

The areal extent of the 500 mb. catalogue is approximately twenty degrees latitude by thirty degrees longitude. This is double the recommended size of windows (Hartranft, 1970a) and is slightly larger than the area used by most authors except Augulis. This large area was deemed necessary due to the scarcity of station data and the unavailability of grid point data. A larger area also seems necessary to adequately describe the flow pattern over Alberta.

4.2.2 Analysis Procedures and Results

The map types were generated using the REMPO technique, and the final results are contained in Appendix 4.

June and July were chosen as the representative period to be used initially. This period was chosen because it coincides with the maximum mean monthly precipitation for most Alberta stations. Map types obtained during

this period would hopefully be useful in studying the occurrence of precipitation. Only the 12Z maps were analyzed in order to decrease the computations.

The Map Typing Project Office has found that the optimum threshold correlation coefficient for upper air maps is 0.90. This threshold was applied to the data sample but it became evident that this value was too large, probably a result of the large area used. The threshold value was decreased to 0.85 for the final map types for the catalogue. Table 3 shows the comparison of the results for each threshold value. In the selection of map types, a minimum cut-off value of one-half percent of the data sample was used below which a map would not be considered a type. With a threshold value of 0.90, twenty-seven types were initially selected and after assignment of all data in every month, thirty-five percent remained uncorrelated. A threshold value of 0.85 produced thirteen types and twenty-four percent remained uncorrelated. The uncorrelated groups for threshold correlation coefficients of 0.90 and 0.85 were considered too large. The uncorrelated groups were separately correlated and additional types selected (0.90 and 0.85 threshold values with selection terminated at one-half percent). The higher threshold (0.90 produced forty-six additional types for a total of seventy-three. The 0.85 threshold produced an additional twenty-two types for a total of thirty-five. The uncorrelated group had dropped to eighteen and twelve percent respectively. Although the use of 0.90 produces more distinct types, the number of them appears to be excessive. The results obtained for a threshold value of 0.85 were used as the map types for the final summer 500 mb. catalogue.

TABLE 3

Map Typing Results for 500 mb. using 0.90 and

0.85 Threshold Correlation Coefficients

Data: 500 mb. heights at nineteen stations. Period of record, May - September 1963-1971 (2,754 maps).

Representative Period:
June and July 1963-1971. 12Z maps only.

Threshold Coefficient	0.90	0.85
Number of Initial Types (cut-off less than 3 maps)	27	13
Uncorrelated Maps After Assignment	956 (35%)	649 (24%)
Additional Types From Uncorrelated Maps	46	22
Total Number of Map Types	73	35
Total Number of Uncorrelated Maps After Final Reassignment	482 (18%)	322 (12%)

It is interesting to note that the date chosen for the key map for Map Type 1 in the final catalogue would have been the same if the threshold value were 0.90. The number of maps occurring for each of the final types in the initial selection and the final assignment is shown in Table 4. The first thirteen types were developed from the representative period (June and July, 549 12Z maps) while the remainder were selected from the uncorrelated group of 649 maps. The importance of the final reassignment phase of the typing procedure, i.e., map assigned to the type with which it correlates most highly, is shown in Table 4. Map Type 8 was the eighth pattern to be selected initially but after the final reassignment of the data base for all months, this type becomes the fourth most predominant (excluding the uncorrelated group).

In the production of the surface map catalogue, a map type which had less than two percent of the development sample assigned to it was not regarded as a map type. This procedure was disregarded for the 500 mb. catalogue and all types selected were retained no matter what the outcome of the reassignment phase. If a one percent cut-off value had been used, one-half the types would have been rejected, whereas a one-half percent cut-off would have resulted in the loss of three types, namely 29, 31, and 34.

TABLE 4

Number of Maps Associated With Each 500 mb. Map Type

Map Type	Number of Maps Initially Assigned	Number of Maps Final Assignment	Percent of Total Data
1	199	525	19
2	58	385	14
3	54	249	9
4	32	126	5
5	21	58	2
6	16	65	2
7	11	40	1
8	9	187	7
9	8	19	1
10	8	27	1
11	7	75	3
12	6	28	1
13	6	15	1
14	38	59	2
15	32	66	2
16	28	51	2
17	23	24	1
18	22	35	1
19	19	55	2
20	18	18	1
21	16	27	1
22	16	26	1
23	13	17	1
24	13	15	1
25	9	64	2
26	9	20	1
27	9	17	1
28	9	36	1
29	9	13	0
30	8	18	1
31	8	13	0
32	7	15	1
33	7	19	1
34	7	7	0
35	7	18	1
U		322	12

Characteristics of the map types were computed for each map type as for the surface catalogue. All statistics were tabulated by month. The statistics illustrate the various motions which can occur for a variety of map patterns. No extensive description can be attempted because of the large amount of data obtained. The next chapter when precipitation and the combination of surface and 500 mb. map types are considered, will cover some map type characteristics. It is worthwhile to note that visual inspection of the key map patterns and characteristics indicate that the area chosen and modifications to the analysis procedure has not produced undesirable results. The area used for the analysis was purposely made relatively large based on the assumption that weather patterns may change drastically over a relatively short period of time. This is evident from the statistics on the following types. Map Type 3, which has a closed-low circulation centered on the coast of British Columbia occasionally changes in twelve hours to a Map Type 15, which has a closed circulation in Northern Alberta.

Retention of all map types obtained, regardless of the outcome of the reassignment phase, may enable the catalogue to be used for seasons other than the one for which it was developed. The weather patterns which occur in other seasons should bear a resemblance to the map types already obtained. The differences will probably be evident only in the map type characteristics.

CHAPTER V

DEVELOPMENT OF SYNOPTIC CLIMATOLOGICAL AIDS

5.1 Climatological Aids From Map Types

Given a catalogue of map types, a variety of synoptic climatological aids can be developed for each map type using weather records from individual stations. Any weather phenomena for which the synoptic flow pattern is the dominant factor such as precipitation, visibility and ceilings could be investigated. Since the catalogue contains statistical information on the type occurrence, the following map type and type duration, it is, in itself, a climatological aid providing useful information on synoptic patterns occurring within the area.

Conditional climatological tables of ceiling and visibility (commonly referred to as "persistence probability" or PP tables) have been in use for many years by most weather detachments in the United States Air Force and Army. A weakness of these PP tables is their inclusion of ceiling and visibility conditions which are due to many different synoptic and smaller scale situations. PP tables of weather variables based upon a factor such as wind direction or surface pressure could likely be improved if they were based on map types.

Hartranft et al (1970a, 1970b) have used map-typing in predicting

heavy snowfall (greater than or equal to two inches) for Colorado Springs. By using a combination of surface and 700 mb. map types, reliable "no" forecasts were obtained, but in order to separate the snow producing storms within each map type, additional screening and parameters such as moisture (surface and aloft) and pressure gradients were needed. Lund (1963) found that useful information could be obtained about probable weather by knowing the map type, i.e., precipitation amount, snowfall amount and percent of possible sunshine at Boston, Massachusetts.

The major advantage of synoptic climatological aids based on computer-derived map types is that the synoptic flow pattern is taken into consideration and prognostic chart information can be incorporated for operational use.

5.2 Comparison of 500 mb. and Surface Map Types

Although the 500 mb. and surface map types have no one-to-one relationship, an examination of surface patterns associated with each 500 mb. type will reveal information concerning the intensity of systems and mean temperature patterns. No quantitative mean thermal patterns can be obtained since the data values for each catalogue were not identical (number of data points and spacing); however, qualitative thermal patterns can be inferred for well developed situations.

After map types for 500 mb. and surface were developed separately, contingency tables of their mutual occurrence were prepared for the period May 1 to September 30, 1963-1971. In all, 1,224 combinations are

possible with the number of types obtained. Considering only primary (i.e., highest correlation) 500 mb. and surface types, it was found that 814 (66.5%) combinations did not occur, whereas when both primary and secondary (second highest correlation coefficient) types were considered, 628 (51.3%) did not occur. One hundred and seventy-seven combinations of primary 500 mb. and surface map types (14.5%) accounted for seventy-seven percent of the days in the nine-year period. Every surface type was possible with only one upper air type, namely number one. This could be expected since this type occurs most frequently and numerous thermal patterns can be envisioned depending on the intensity of the upper air flow.

The five most frequent primary surface types associated with each 500 mb. type are shown in Table 5. The most frequent surface type associated with an upper air pattern is the uncorrelated group, a result not surprising since this group occurs most frequently in the summer and is a result of poorly organized weather systems. The strong similarity between surface Types 2 and 17 has previously been mentioned in section 3.4. Map Type 17 occurs more frequently than Type 2 with the 500 mb. Types 6, 18, 20, and 29, each characterized by a ridge west of Alberta. An inspection of upper air patterns which are associated with Map Type 2, indicates that they all are characterized by a trough west of Alberta.

TABLE 5

Predominant Surface Map Types and Frequency Associated With Each 500 mb. Map Type (May - September, 1963-1971)

Primary 500 mb. Map Type	Number of Maps	Primary Surface Map Types (Frequency %)				
1	525	U(32)	4(16)	2(15)	9(7)	13(4)
2	385	U(38)	2(15)	4(12)	9(6)	7(4)
3	249	U(34)	4(11)	2(10)	9(6)	14(5)
4	126	U(45)	4(17)	6(9)	7(4)	13(4)
5	58	U(38)	9(16)	2(12)	25(9)	14(7)
6	65	U(52)	17(9)	27(9)	1(6)	2(5)
7	40	4(35)	U(28)	14(10)	10(8)	25(8)
8	187	U(34)	9(14)	12(14)	3(11)	2(6)
9	19	U(68)	1(11)	19(11)	9(5)	10(5)
10	27	U(63)	27(15)	23(7)	1(4)	2(4)
11	75	U(28)	4(25)	2(12)	3(5)	9(4)
12	28	1(32)	U(18)	4(14)	19(11)	6(7)
13	15	U(57)	25(27)	2(7)	19(7)	26(7)
14	59	U(34)	4(17)	6(8)	7(8)	9(8)
15	66	4(53)	U(12)	14(8)	2(5)	6(5)
16	51	U(22)	9(18)	2(12)	28(10)	3(8)
17	24	U(46)	1(13)	6(8)	19(8)	2(4)
18	35	U(40)	10(11)	27(11)	1(9)	17(6)
19	55	U(49)	2(11)	10(9)	5(7)	26(7)
20	18	U(39)	9(17)	17(17)	2(11)	12(6)
21	27	U(44)	4(26)	25(11)	1(7)	9(4)
22	26	U(54)	12(12)	5(8)	19(8)	1(4)
23	17	U(41)	9(18)	7(12)	27(12)	4(6)
24	15	U(60)	19(13)	1(7)	6(7)	12(7)
25	64	2(25)	4(20)	U(19)	13(17)	6(5)
26	20	U(55)	23(15)	1(5)	2(5)	11(5)
27	17	4(41)	U(18)	6(12)	14(12)	9(6)
28	36	U(47)	27(19)	10(8)	12(8)	2(3)
29	13	U(54)	4(8)	10(8)	12(8)	17(8)
30	18	4(56)	9(17)	2(6)	14(6)	25(6)
31	13	U(62)	4(8)	7(8)	9(8)	23(8)
32	15	U(40)	30(27)	1(13)	19(7)	26(7)
33	19	4(58)	U(21)	13(11)	19(5)	25(5)
34	7	U(71)	20(14)	30(14)		
35	18	4(28)	U(28)	26(11)	6(6)	7(6)
U	322	U(41)	4(9)	6(6)	14(6)	19(6)

By considering the upper air and surface patterns, the intensity and mean temperature patterns of systems could be inferred. The large amount of information precludes any complete discussion of results. The evolutionary aspect of each paired type for the day of occurrence and succeeding time periods could be important in connection with forecasting applications.

5.3 Probabilities of Precipitation From Map Types

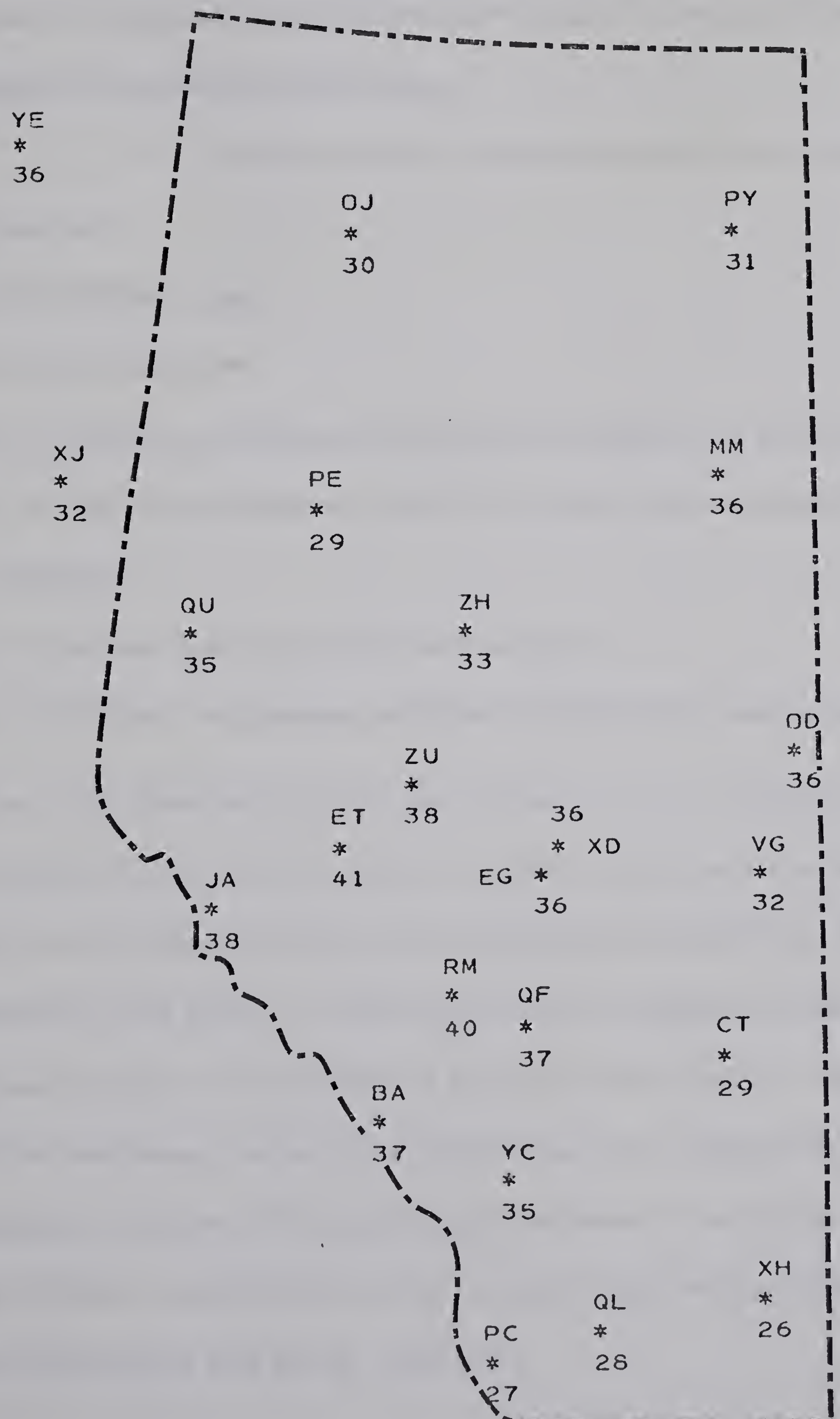
5.3.1 Precipitation Data and Analysis Procedures

Precipitation data were obtained from Monthly Records published by the Atmospheric Environment Service (AES) for twenty-three first order observing stations in Northeastern British Columbia and Alberta for the period May to September 1963-1971 (1,377 days). The station locations and identifiers used are illustrated in Figure 5. Since the map type catalogues were obtained by using data at 00Z and 12Z, precipitation amounts should preferrably be centered at these times. This would allow both map type times to be used in developing precipitation frequency (hereafter referred to as precipitation probabilities or PoPs). The only easily available data are a twenty-four hour precipitation amount based on the standard climatological day (06Z-06Z). Precipitation amounts were not used for climate stations because the times of observation are so variable and difficulty would be experienced in associating the precipitation to the map type times. No attempt was made to distinguish convective and continuous precipitation. Snows of early May and late September were also not differentiated.

FIGURE 5

Stations for Precipitation Study and Climatic Probabilities

of Measureable Precipitation



The use of twenty-four hour precipitation amounts required some decision as to the map type time to be used in computing PoPs. The 12Z (6 AM MDT) map type was chosen to compute the probabilities as this was only six hours after the beginning of the precipitation day and was usually prior to the development of convective precipitation.

Various correlations for obtaining PoPs from the data and map types are:

(i) 12Z 500 mb. type

(ii) 12Z surface type

(iii) 12Z 500 mb. and surface types (referred to as 500 mb. - surface)

(iv) 12Z 500 mb. and following 00Z 500 mb. types (referred to as 500 mb. - 500 mb.)

(v) 12Z surface and following 00Z surface types

(vi) 12Z 500 mb. and surface and following 00Z 500 mb. and surface types.

PoPs were calculated using the first four methods (i - iv). The first two were not expected to give the best results but hopefully would provide probabilities which were significantly different from climatological probabilities. The combination of the 500 mb. - surface types would be expected to produce the best results since the thermal pattern is being taken into account. Hage (1957) has found that abrupt changes in the 500 mb. flow occur during intense lee cyclogenesis in Alberta. This was the principal reason for computing PoPs using the 12Z 500 mb. and 00Z 500 mb. map types and should produce better results than considering the 12Z 500 mb. type only.

The occurrence of precipitation was defined using a threshold value of 0.01 inches or more, and was based on work by other authors. It may be more useful to increase this value or compute PoPs for different ranges of precipitation values. The present objective of this work, however, was to show that significant improvement over climatological probabilities is obtained by taking the synoptic flow pattern into consideration.

A map for any given day can correlate above the threshold correlation coefficient with one or more of the catalogue types. To take this into account, the highest and second highest correlations were computed and retained. This would indicate that the pattern for this particular day is a combination of two map types and could be classed as a "hybrid" type. In obtaining the PoPs, two approaches can be taken. First, the pattern can be considered unique and PoPs can be computed for this "hybrid" type, or, the precipitation occurrence or non-occurrence can be associated with each type separately. The latter method would have the effect of increasing the data base and stabilizing the probabilities. This method would prove to be beneficial provided there was no drastic increase or decrease in the probabilities. A test was carried out when the PoPs were computed for the 500 mb. map types. Initially, only the primary map type was used. This provided a data base of 1,377 observations. The probabilities were then recomputed using both primary and secondary type, if any. This procedure increased the data base to 2,24[illegible]. An inspection of both results indicated an average mean change in the probabilities of approximately five percent, with changes rarely in excess of ten percent. The largest changes occurred for those map types which had relatively few occurrences. Because the

results of the above showed a large increase in the data base and little change in the probabilities, it was decided that the use of both the primary and secondary map type, if any, would be most beneficial.

Table 6 indicates the increase in the data base when both primary and secondary map types were used for each of the four methods.

TABLE 6

Increase in Data Base for Probabilities of Precipitation

Classification Method	Primary Types	Primary & Secondary	Percent Increase
12Z 500 mb.	1377	2246	63
12Z Surface	1377	1791	30
12Z 500 mb. & 12Z Surface	1377	2948	109
12Z 500 mb. & 00Z 500 mb.	1377	3862	180

The climatological probabilities of measureable precipitation for each station were calculated for the entire summer season (May to September) using the latest thirty year precipitation normals (1941-1970) published by the AES. The probabilities for each station for any one day are illustrated in Figure 5 (page 52).

5.3.2 Results

The probabilities of precipitation for the 500 mb. map types are shown in Appendix 5. The results indicate that significant departures from climatological probabilities are obtained. An investigation of the PoPs for the most frequently occurring types indicate interesting results. The most predominant pattern is Map Type 1. This type is characterized by a trough in central B.C. with a west to southwest flow over Alberta. The PoPs show an increased probability from climatology in the far northern stations (YE, OJ, MM), a decrease in southern Alberta and little or no change elsewhere. The decrease in the south is attributable to the subsidence flow over the Rocky Mountains, while the increase in the north is due to the cyclonic curvature of the flow. Map Type 2 results show a decrease over the southern half of Alberta as a result of a flat ridge predominating. Map Type 3 produces an increase over climatology because of increasing cyclonic flow, especially in the northern areas,while decreases with Map Type 8 are produced by ridging.

The uncorrelated group, which contains various map patterns, also provides encouraging results. This type yields lower PoPs than climatology over northeastern Alberta and higher values in the south.

An examination of all results indicate that areas of high and low PoPs are obtained by considering different flow patterns, with ranges of probabilities from zero to one hundred percent. The values of one hundred percent however, cannot be considered significant since this type occurred only five times. The results appear reasonable and can be explained qualitatively in terms of our knowledge of map patterns and precipitation. It is also obvious that

for various map types, the precipitation probabilities are near the climatological probabilities. This indicates that more parameters need to be investigated.

The surface map PoPs are contained in Appendix 6 and the results are similar to those for the 500 mb. types. The ranges of values are again from zero to one hundred percent. The values of one hundred percent should not be considered significant due to the small number of cases, and also the probabilities for Map Types 16, 18, 21, 22 and 29 which had five or fewer occurrences in nine years.

The PoPs for surface types 2 and 17 are especially interesting. It has previously been mentioned (sections 3.4 and 5.2) that these two patterns are highly similar with Type 2 being more developed. This supposition about development is confirmed by the PoPs. The probabilities for Map Type 2 indicate lower than climatology for southern Alberta and along the Rocky Mountains as far as XJ, and higher probabilities in far northern Alberta. The results for Map Type 17 show low probabilities for all stations, not only significantly lower than climatology, but generally one-half the values of Type 2.

The results for the uncorrelated group are much less encouraging than the 500 mb. The surface uncorrelated group is the most predominant summer type, but little or no improvement over climatology is indicated.

The probabilities for the combinations of 12Z 500 mb. and 12Z surface, or 12Z 500 mb. and following 00Z 500 mb. are contained in Appendices 7 and 8, respectively. The final results retain only those

combinations which were considered important. Initially, the 500 mb. - surface and the 500 mb. - 500 mb. PoPs resulted in 490 and 415 distinct classifications respectively. Many had few occurrences so it was decided to disregard any classification which had fewer than ten occurrences. These cases were not totally disregarded, but were used to compute PoPs when no significant surface or 00Z 500 mb. type occurred. An example of the use of these PoPs can best be explained by referring to Map Type 1 (Appendix 7). If the 500 mb. is Map Type 1, the important surface map classifications are Types 2, 3, 4, 5, 6, 7, 9, 12, 13, 14, 17, 28 and U. The PoPs for all other surface types had fewer than ten occurrences,so they were all combined and are listed in the last classification. If the surface type is not one of the important classification, the last is the one to use. This procedure decreased the number of combinations to 107 and 108 for the 500 mb. - surface and 500 mb. - 500 mb., respectively.

Classification of the 500 mb. and surface pattern simultaneously generally yields improved results over considering the types separately. This result was expected since the three-dimensional, i.e., thermal aspect of the atmosphere is being taken into account. There are, however, certain combinations which do not change the probabilities from those of the 500 mb. or surface. No attempt was made to test the significance of a particular combination other than by the number of occurrences. It is again worthwhile to note that differences in PoPs for surface May Types 2 and 17 with an upper air pattern are still apparent as was the case when they were considered separately.

The combination of 12Z 500 mb. and the following 00Z 500 mb. PoPs (Appendix 8) indicate some improvement over using the 12Z 500 mb.

type alone. When there is no change in type from 12Z to 00Z, the probabilities are virtually identical with those of Appendix 5. When there is a change in type, the PoPs increase or decrease in magnitude depending on the degree and type of change (i.e., trough becoming ridge or vice versa) in the pattern.

5.3.3 PoPs Verification Using Brier Scores

In order to evaluate the ability of the above four methods to forecast the probability of rain occurrence, the Brier Score and related statistics were computed using the development sample. Brier Scores provide a convenient numerical verification of probability forecasts. Included is a measurement of both "reliability" and "resolution" factors. The "reliability" of the forecasts is the agreement between the forecast probability and observed frequency of occurrence of the event. The "resolution" measures the skill in assigning to the forecast values of probability which deviate from the climatological frequency.

In Appendix 11, it is shown that the average Brier Score for M_k forecasts in the k^{th} probability category (i.e., 0, 10, 20, . . ., 100%) is:

$$B_k = (F_k - \emptyset_k)^2 + \emptyset_k (1 - \emptyset_k) , \qquad (2)$$

where F_k is the forecast probability and $\emptyset_k$ is the actual relative frequency of occurrence. The first term on the right hand side of (2) is the reliability term, while the second is the resolution. The reliability term becomes a minimum when F_k equals $\emptyset_k$. On the other hand, the resolution term becomes a minimum when

$\emptyset_k$ is either zero or one hundred percent (i.e., equal to one) and a maximum at $\emptyset_k$ equals fifty percent. It can be seen that if the reliability is fairly good (i.e., that term is small), the poorest separation of forecasts (resolution term) results in the highest Brier Score.

The average Brier Score for all probability categories is obtained by averaging the mean scores for each category, weighted by the number of forecasts in that category. Thus,

$$B = \frac{1}{M} \sum_k M_k B_k \quad , \tag{3}$$

where M equals the total number of forecasts. Possible values of "B" range from zero to one, with zero the best score.

Two additional statistics which are useful in comparing forecasts are the root-mean-square error in reliability (RMSE) and the skill score based on a comparison with a simple control forecast. The first of these is defined by:

$$RMSE = \frac{100}{M} \sum_k M_k \left\{ F_k - \emptyset_k \right\}^2 \quad , \tag{4}$$

and the skill score by:

$$S = 100 \left\{ 1 - \frac{B}{cB} \right\} \quad , \tag{5}$$

where B is the average Brier Score obtained by employing the forecast probabilities and cB, the Brier Score obtained by using the climatological frequency or persistence as the forecast probability.

All the above parameters were computed for each of the PoPs obtained. Eleven subsets of forecast probabilities were defined and are indicated in Table 7. In applying the derived PoPs, only the primary map types were used in arriving at a probability forecast, whereas both primary and secondary types had been used in the derivation. Skill scores were computed using both climatological frequency (based on period May to September) and persistence as the control forecast. It was found that the map type PoPs were better than

Table 7

Probability Subsets and Ranges for Brier Score Computations

Probability Subset K	Probability Range for Subset
0	0 - 4
10	5 - 14
20	15 - 24
30	25 - 34
40	35 - 44
50	45 - 54
60	55 - 64
70	65 - 74
80	75 - 84
90	85 - 94
100	95 - 100

persistence by a substantial amount, however, climatology was also better than persistence. As a result, persistence was disregarded as a control forecast for summer precipitation. The calculated RMSEs are exceedingly small (less than 0.5 percent) for all four methods and for all stations as expected. The reliability term, therefore, contributes little to the Brier Score and it is the resolution term which is the dominant factor. Table 8 illustrates the computed skill scores for each station and each map type PoPs classification using the climatological frequency of measureable precipitation as the control forecast. The underlined values for each station refer to the highest computed skill score while the dashed values are scores within one percent of the highest value.

The best improvement over climatology is obtained for most stations by using the combination of 12Z 500 mb. and 12Z surface types. Only seven stations differed from the above and five of these were using the classification method of 12Z 500 mb. and following 00Z 500 mb. map type. The two remaining stations (CT and RM) obtained the best results from using only the 12Z surface type. It should be noted however that for these seven stations, the 500 mb. - surface combination skill scores were within one percent of the highest results. The 500 mb. - 500 mb. classification is preferable to using only the 12Z 500 mb. type in all cases. This result was anticipated since a twenty-four hour precipitation period was used but this may not be the case if a shorter time period is used.

TABLE 8

Skill Scores (Percent) Using Primary Map Types for Development Sample

(May - September, 1963-1971)

Station	500 mb.	500 mb. - 500 mb.	Surface	500 mb. - Surface
XJ	8.8	7.5	10.5	12.6
YE	5.0	5.2	8.5	8.0
CT	9.9	14.4	11.2	13.4
EG	9.9	11.7	11.2	13.3
XD	9.2	11.2	10.9	12.8
RM	11.9	17.7	14.2	16.8
VG	10.5	9.3	11.7	16.5
QF	13.2	16.0	16.0	18.5
YC	16.3	19.5	21.7	20.8
QL	16.9	16.3	19.8	21.8
XH	13.5	11.1	16.5	16.8
PC	19.2	17.6	22.2	24.5
BA	17.9	12.4	18.9	21.8
JA	10.8	8.1	12.8	14.9
ET	11.0	13.4	12.3	16.3
MM	7.2	6.8	11.3	10.6
ZH	10.5	7.2	13.8	14.2
ZU	8.9	12.2	9.2	14.5
PY	6.3	8.3	8.7	9.8
OJ	6.5	4.7	8.4	10.0
QU	9.3	8.1	10.6	14.5
PE	8.4	7.3	11.9	11.7
OD	10.3	7.9	13.7	13.4

It is also interesting to note that the greatest improvements over climatology is obtained for stations in central and southern Alberta. This result indicates that the synoptic flow is an important factor for precipitation in central and southern Alberta. This may be related to the height and proximity of the Rocky Mountains.

A comparison of the observed frequency of precipitation to forecast probability for each probability category (not shown) indicates that for low probabilities, the forecast probabilities are generally too low, while in higher probabilities, the forecast values are too high. This problem has been reported in previous studies, e.g., Saunders (1963), and represents "over-confidence" by the method, that is, the method over-estimates its skill in separating the forecasts into the extreme ends of the probability range. This may be the result of too few cases in the derived PoPs.

The skill scores for any method show only moderate improvements over climatology at any station. This is because too many forecasts are made at the climatological frequency of precipitation. Ideally, the forecast probability distribution should have maxima above and below the climatological probabilities (ideally at zero and one hundred percent). This occurs only for those stations having a skill score of greater than twenty percent and even in these cases, the maximum number of forecasts is much greater at the low ranges than at the high ranges. An example for Lethbridge (QL) is illustrated in Figure 8, Appendix 11.

These results indicate that for the development sample (May to September 1963-1971), improvement over climatological precipitation probabilities is obtained by taking the synoptic flow pattern into consideration. PoPs verifications using map types on an independent data sample (May - September 1972-1973) were calculated. They are discussed in the following chapter.

CHAPTER VI

RESULTS FOR INDEPENDENT DATA SAMPLES

6.1 Surface and 500 mb. Map Types 1972 and 1973

The independent data sample, to test the results of the map catalogues and PoPs, consisted of 612 days for the period May to September 1972 and 1973. The data for this period consisted of 500 mb. heights and mean sea level pressure values covering the area of the map catalogues. Twenty-four hour precipitation amounts for the periods 06Z - 06Z and 18Z - 18Z were obtained from Monthly Summaries and from the Edmonton Weather Office. The verification results for the PoPs are discussed in section 6.2.

The map times of 00Z and 12Z for each day were correlated against the key map pattern for the surface and 500 mb. catalogues. Each map was associated with that map type for which the correlation coefficient was the highest provided it exceeded or equalled the threshold values of 0.80 for the surface or 0.85 for the 500 mb. types. Any map which correlated below the threshold value with all key maps was assigned to an uncorrelated group. The frequencies of occurrence of each map type during the independent data period are presented in Table 9.

TABLE 9

Number and Frequency of Occurrence (%) of Primary 500 mb. and Surface Map Types for May - September 1972-1973

Map Type	500 mb.	Surface
1	113(18)	13(2)
2	76(12)	47(8)
3	47(8)	10(2)
4	23(4)	73(12)
5	14(2)	12(2)
6	8(1)	13(2)
7	4(1)	14(2)
8	55(9)	9(1)
9	10(2)	35(6)
10	1(0)	8(1)
11	36(6)	1(0)
12	5(1)	12(2)
13	3(0)	21(3)
14	17(3)	6(1)
15	11(2)	2(0)
16	7(1)	1(0)
17	1(0)	7(1)
18	6(1)	-
19	5(1)	3(0)
20	6(1)	3(0)
21	2(0)	-
22	2(0)	-
23	2(0)	4(1)
24	9(1)	15(2)
25	9(1)	15(2)
26	8(1)	12(2)
27	2(0)	12(2)
28	5(1)	1(0)
29	2(0)	2(0)
30	3(0)	5(1)
31	2(0)	2(0)
32	5(1)	2(0)
33	5(1)	-
34 or U	1(0)	265(43)
35	7(1)	
U	109(18)	

The results for 500 mb. indicate very little change in map type frequency between the dependent and independent data samples. The uncorrelated group frequency shows the highest increase of six percent, making it the second most recurring map type. Map Type 1 remains the predominant pattern with the five most frequent types remaining the same in both samples although their relative order has changed.

The surface map types indicate very little difference in frequencies of occurrence between dependent and independent data samples, the mean change being one percent. As with the 500 mb., the uncorrelated group frequency shows an increase of nine percent, with this group remaining the predominant type. The five most predominant types and their relative order have shown no change, while Types 18, 21, 22 and 33 have not occurred.

6.2 PoPs Verification for 1972 and 1973

The precipitation probabilities were verified for each of the derived methods based on the Brier Score and using the same procedure as in section 5.3.3. The occurrence of precipitation was defined as an amount of 0.01 inches or more.

The computed root-mean-square errors in the reliability (RMSE) and the skill scores for the precipitation period 06Z-06Z are contained in Tables 10 and 11, respectively.

TABLE 10

Root-Mean-Square Errors in Reliability (%) for Independent Data

(Precipitation Period 06Z-06Z)

Station	500 mb.	500 mb. - 500 mb.	Surface	500 mb. - Surface
XJ	0.3	0.3	0.3	0.5
YE	1.5	1.8	1.3	1.4
CT	0.7	1.0	0.8	1.1
EG	1.6	1.2	1.9	0.8
XD	1.8	1.9	1.4	1.6
RM	1.4	0.8	0.6	0.5
VG	1.1	1.2	0.8	0.9
QF	1.6	0.7	0.5	1.7
YC	1.5	1.0	0.8	1.2
QL	0.4	0.4	0.6	0.3
XH	1.0	0.7	0.7	1.7
PC	3.0	1.7	0.8	1.6
BA	1.0	1.1	1.1	1.4
JA	0.2	0.9	1.1	0.8
ET	1.2	1.4	1.0	1.9
MM	1.8	1.9	1.1	1.6
ZH	2.3	1.4	1.7	1.4
ZU	2.5	2.5	3.1	2.5
PY	0.9	2.5	0.3	1.3
OJ	1.0	1.1	1.5	1.2
QU	0.8	1.2	1.1	1.3
PE	1.2	1.7	1.6	2.1
OD	1.7	2.3	0.8	1.6

TABLE 11

Skill Scores for Independent Data (Precipitation Period 06Z-06Z)

Station	500 mb.	500 mb.-500 mb.	Surface	500 mb. - Surface
XJ	3.0	3.5	5.9	4.4
YE	- 0.5	- 2.4	2.8	0.7
CT	5.3	5.9	5.7	4.1
EG	4.0	4.2	3.0	6.0
XD	1.3	0.3	2.3	2.2
RM	10.2	13.6	20.6	12.5
VG	2.1	1.7	6.9	2.0
QF	5.2	9.4	12.1	5.2
YC	13.0	17.8	12.8	17.3
QL	19.7	19.1	8.5	22.1
XH	7.6	7.4	7.0	10.6
PC	5.0	9.5	6.6	8.9
BA	14.4	16.0	6.5	13.9
JA	6.4	4.9	1.5	3.4
ET	2.9	3.1	6.7	3.1
MM	- 0.1	1.0	10.4	3.6
ZH	- 0.7	2.0	5.6	4.1
ZU	- 2.7	- 1.9	0.8	- 2.2
PY	- 1.5	- 2.6	7.3	1.5
OJ	2.7	3.7	3.4	3.4
QU	2.3	4.1	1.8	0.2
PE	2.3	3.0	3.2	- 0.6
OD	0.2	- 3.5	7.9	2.3

The RMSEs for all stations have shown an increase over these of the development sample but the maximum value is less than 3.5 percent. This remains well below the average value of 11.3 percent reported by Nikleva (1971) for subjective probability forecasts for six fire weather forecast locations for the period May to September 1965 to 1969. The present study's results appear to be highly favourable in this regard.

The low RMSE values indicate that the derived PoPs are reliable. The contribution of the reliability term to the total Brier Score is less than ten percent, the maximum being thirteen percent for Whitecourt (ZU) using the surface map type alone.

The computed skill scores (Table 11) exhibit some interesting results. The most noticeable aspect is the occurrence of negative skill scores, implying that no improvement over climatology has been obtained by using map types. It has previously been mentioned that the improvement over climatology for stations north of a line ET-XD-VG was generally much lower than those for southern stations. The negative skill scores reaffirm this pattern. Also, the classification method producing the highest skill scores are greatly different. The underlined values in Table 11 indicate the highest skill score for that station and the dashed line indicates differences of less than one percent from the highest score. For the dependent data, the best combination of types appears to be the 500 mb. - surface, since these produced the highest scores most frequently. For the independent data, this combination produced the highest scores for only three stations (EG, QL, and XH) compared with sixteen stations previously. Similarly, the surface map type produces the best results for

Rocky Mountain House (RM) for both data samples while for Coronation (CT), this is true for the dependent data only. The 500 mb. - 500 mb. and surface map type skill scores for CT differ by only 0.2 percent however. The motion of the upper air pattern (500mb. - 500 mb. combination) results in the highest verification for Calgary (YC) in both data samples. All stations except RM and QL experienced decreases in skill scores compared to the dependent data, with QL continuing to show the highest results of all.

It is of interest to point out the results for XJ and QL. The RMSEs in reliability (Table 10) are nearly identical for both stations for all methods, averaging 0.4 percent. The skill scores (Table 11) for the same two stations show substantial differences, average 4.2 percent for XJ compared with 17.4 percent for QL. These differences in the skill scores are the result of the resolution of the forecasts. A greater proportion of the QL forecasts are above or below the climatological frequency of measureable precipitation compared to XJ.

Since only a twenty-four hour precipitation amount was available, one-half of the 612 maps in the independent data sample could not be used in the previous PoPs verification (namely, 00Z map types). A twenty-four hour precipitation amount for the period 18Z-18Z was available for 1972-1973 but not for the development sample. The derived PoPs were used for this precipitation period with the 00Z map type replacing the 12Z type. If the verification results were acceptable, a benefit would be obtained since all map types could be used.

The RMSEs and the skill scores for the precipitation period 18Z-18Z are shown in Tables 12 and 13, respectively. The RMSEs in reliability are similar to those in Table 11, implying that the reliability term contributes little to the total Brier Score.

The skill scores indicate differences between the development data and the results discussed above. The skill scores are lower than the dependent data values for all stations while there has been increases and decreases in scores from the 1972-1973 data using the 12Z types. Medicine Hat (XH) is the only station which has consistently experienced the highest value with one map type combination, namely the 500 mb. - surface. The high scores are now mostly produced by the classifications using either the 500 mb. only or the 500 mb. - 500 mb. types (thirteen of twenty-three); the greatest increases occurring for the 500 mb. type only. This effect may indicate that convective precipitation in summer is controlled by preferred 500 mb. flow patterns.

An investigation of the number of forecasts in each probability category for all stations indicate that there are many forecasts at or near the climatic frequency of measureable precipitation. This explains the lack of great improvement over climatology and indicates that more variables are required.

TABLE 12

Root-Mean-Square Errors in Reliability (%) for Independent Data

(Precipitation Period 18Z-18Z)

Station	500 mb.	500 mb. - 500 mb.	Surface	500 mb. - Surface
XJ	0.2	0.5	1.0	1.0
YE	0.6	1.2	1.1	1.0
CT	0.4	1.0	1.3	1.2
EG	0.3	0.9	0.6	0.5
XD	0.6	0.5	0.8	0.7
RM	1.1	1.0	1.1	0.8
VG	1.6	1.0	1.0	1.5
QF	1.2	0.7	0.6	1.3
YC	1.5	1.1	0.5	1.6
QL	0.6	0.8	1.8	1.1
XH	1.2	0.4	0.5	1.3
PC	1.3	0.3	0.8	0.8
BA	0.7	0.7	0.9	0.4
JA	0.4	1.2	0.6	0.9
ET	1.0	1.2	0.6	0.7
MM	1.4	1.6	0.7	1.3
ZH	1.3	1.0	0.8	2.4
ZU	1.9	1.6	1.1	2.1
PY	0.5	0.7	0.4	1.1
OJ	0.6	1.6	0.5	1.0
QU	0.4	0.7	1.5	0.8
PE	1.0	0.9	0.9	1.2
OD	1.6	1.4	0.7	2.1

TABLE 13

Skill Scores (%) for Independent Data

(Precipitation Period 18Z-18Z)

Station	500 mb.	500 mb. - 500 mb.	Surface	500 mb. - Surface
XJ	4.0	2.3	1.6	0.2
YE	6.5	3.6	5.3	6.6
CT	7.2	6.1	- 0.1	2.8
EG	11.3	11.7	6.2	8.4
XD	6.6	7.5	6.7	5.3
RM	13.4	12.5	11.3	12.0
VG	0.6	3.2	3.0	0.6
QF	9.1	12.6	8.0	9.1
YC	17.9	16.2	9.5	17.7
QL	20.3	18.4	- 2.0	18.6
XH	8.7	7.4	2.7	9.3
PC	13.0	13.3	5.2	13.4
BA	13.8	18.7	10.7	12.7
JA	10.3	4.6	3.3	3.5
ET	4.6	5.5	11.5	4.3
MM	0.4	- 0.4	9.5	3.4
ZH	6.0	6.4	10.1	6.8
ZU	- 0.3	1.9	5.4	- 2.0
PY	1.3	2.6	4.6	- 0.3
OJ	1.3	- 2.8	2.3	0.1
QU	6.6	4.8	1.4	4.1
PE	7.7	5.3	4.3	5.1
OD	- 2.4	- 2.9	2.6	- 2.0

When the PoPs statistics were initially computed for the 500 mb. - surface and 500 mb. - 500 mb., 490 and 415 combinations,respectively, had occurred (section 5.3.2). It was arbitrarily decided that any combination having less than ten occurrences was probably not significant and these cases were not retained as a separate entity. In order to test the effect of this decision, verification statistics were computed for 1972-1973 using all possible combinations for the 500 mb. - surface classification. The results indicate a degradation in the skill scores for all except a few stations. Negative skill scores are obtained for a greater proportion of stations, even for those which had positive skill scores previously. There is, however, some improvement for three stations in both the 06Z-06Z and 18Z-18Z precipitation periods. For the period 06Z-06Z, RM (20.0%), XH (10.7%), and ET (4.0%) show an increase, while for 18Z-18Z, RM (14.5%), XH (8.7%) and MM (6.2%). It is especially noteworthy that RM consistently shows an improvement, in fact, the resulting skill scores would be near or the highest for the independent data. Although the verification was not performed using all 500 mb. - 500 mb. combinations, there is no reason to believe that the results would be much different.

The verification generally confirms the necessity of rejections of combinations which have few occurrences. It is probable, however, that the arbitrary value of ten in nine summers is not the most desirable.

The verifications indicate that improvement over climatic frequency of precipitation is obtained, notably for southern stations, by classifying the data into different flow patterns. The improvement is highly variable over the area verified and may be result of the highly irregular

topographic features or not distinguishing between convective and large-scale precipitation. No one classification method produces the best results for every station and this may also be a result of topography or convective activity. The derived probabilities of precipitation for 06Z-06Z can also be used for the period 18Z-18Z provided the 00Z map types are used instead of the 12Z types.

6.3 PoPs and Verification Using a Higher Precipitation Threshold

Initially PoPs were derived using a threshold of 0.01 inches or greater. This value was chosen following the work of other authors but may not be realistic. The synoptic flow pattern may not be as dominant an influence on low precipitation amounts as on higher values. In order to provide an indication of this possible effect, PoPs were calculated for the 12Z 500 mb. and 12Z surface map types for the development sample using a threshold value of 0.10 inches or greater and the precipitation period 06Z-06Z. This higher threshold value should tend to eliminate the precipitation occurrences due to weak synoptic features and convective activity.

Both primary and secondary map types were used to obtain the PoPs to increase the data base and obtain more stable probabilities. The climatic frequency of precipitation occurrence was computed for this threshold value and are shown in Table 14. The values are relatively constant for all stations and show a decreasing tendency towards the south.

TABLE 14

Climatic PoPs (≥ 0.10 in.) and Verification Skill Scores For

May - September, 1972-1973 (Precipitation Periods 06Z-06Z and 18Z-18Z)

Station	Climatic PoPs	12Z 500 mb.	12Z Sfc.	00Z 500	00Z Sfc.
XJ	17	- 3.0	- 4.6	5.0	3.2
YE	17	- 3.6	- 0.6	- 0.2	2.5
CT	12	2.0	8.0	3.8	- 1.5
EG	17	1.4	6.2	2.5	5.1
XD	17	1.1	5.6	4.6	4.5
RM	22	7.1	15.3	9.7	4.6
VG	17	1.8	3.5	- 0.8	1.2
QF	18	6.0	11.3	7.3	3.8
YC	15	7.2	11.2	6.9	5.2
QL	12	10.4	8.3	8.0	0.1
XH	10	1.2	4.8	4.1	2.1
PC	13	3.8	9.7	2.6	10.6
BA	17	3.2	4.0	- 0.2	4.1
JA	15	4.3	- 0.6	4.2	2.0
ET	22	2.2	- 1.9	4.5	5.9
MM	21	- 3.9	0.4	0.6	3.1
ZH	20	- 2.5	0.6	2.7	3.7
ZU	19	1.7	1.5	0.5	4.2
PY	17	- 1.6	2.2	- 0.4	2.9
OJ	15	1.1	- 2.8	1.3	- 0.9
QU	15	0.6	- 4.9	5.7	0.1
PE	14	- 0.3	- 3.4	7.8	- 1.2
OD	18	- 2.1	4.8	- 0.2	0.7

The resulting PoPs for both 500 mb. and surface are contained in Appendices 9 and 10, respectively. The probabilities are lower than those at 0.01 inches but the departures from the climatic values are similar. Areas of high and low probability are grouped together in different areas depending upon the flow pattern. The ranges of values are similar for both types, namely from zero to eighty percent, with the low values predominating. The PoPs again exhibit the tendency of being too close to the climatic PoPs. No attempt was made to repeat the computations for combinations of map patterns.

Verification results were computed for 1972-1973, using both precipitation periods as before. The RMSEs (not shown) are less than five percent, indicating that the forecast probabilities are reliable. The skill scores are shown in Table 14 with the underlined values being the highest value and the dashed line, within one percent of the highest.

The skill scores for the 12Z types are highly similar to previous results for the majority of stations. There are notable exceptions such as the improvement at ZU and the degradation at Fort St. John (XJ) and Fort Nelson (YE). The best results are evident once more in southern stations while northern ones produce most of the negative scores. The greatest proportion of stations experience the best scores with the surface map type, notably RM (15.3%) as was the case previously. The skill scores for the precipitation period 18Z-18Z yield similar results as for the 0.01 inch threshold (Table 14). The highest values are nearly equally divided between the 500 mb. and surface patterns. Shifts in the highest values are evident along with increases and decreases in values. The results indicate that the derived PoPs are suitable for the 18Z-18Z precipitation

period provided the 00Z map type is used.

Although the evidence is not conclusive, it appears that more experimentation is required in deciding on the threshold precipitation value. Significant precipitation, including convective activity, would be more dependent on the synoptic flow pattern and therefore a higher threshold value may be preferrable. The question of what is significant precipitation would depend on the type of climatological aid that is required.

6.4 Comparing Summer 500 mb. Map Types to Those of Winter

Although the 500 mb. map types were produced from the May to September period, weather patterns which occur in other seasons should bear a resemblance to the map types already obtained, probable differences being evident in frequencies of occurrence and other map type characteristics. Upper air map types were therefore computed using the predetermined summer key patterns for a small data sample of 281 maps (00Z and 12Z) for the period November 1, 1973 to March 21, 1974 inclusive.

The number of occurrences and corresponding frequency for each map type is shown in Table 15. A total of thirteen types did not occur during this data sample and is probably due to the small data period used. Some may be missing because the pattern is not possible at this time of year, the result of the shift in the thermal gradient southwards. Definite conclusions require a larger data sample to be processed.

TABLE 15

500 mb. Map Type Occurrences and Frequency (%) (Winter, 1973-1974)

500 mb. Map Type	Number of Occurrences (Frequency %)
1	68(24)
2	38(14)
3	14(5)
4	9(3)
5	7(2)
6	8(3)
7	-
8	14(5)
9	-
10	12(4)
11	29(10)
12	-
13	-
14	24(9)
15	1(0)
16	5(2)
17	1(0)
18	-
19	5(2)
20	-
21	-
22	-
23	1(0)
24	-
25	5(2)
26	2(1)
27	-
28	-
29	1(0)
30	1(0)
31	-
32	6(2)
33	1(0)
34	-
35	2(1)
U	27(10)

Changes in the relative frequencies of occurrence between summer and winter are suprisingly very minor. Map Type 1 frequency has increased by five percent and this pattern continues to be the predominant one. The uncorrelated group frequency has, on the other hand, decreased slightly. The increased frequency of Map Types 11 and 14 has resulted in their being included in the five most predominant patterns for winter. The summer frequencies of these map patterns were, however, much lower.

Although greater amounts of data must be processed before making firm conclusions, present indications suggest that the derived map types as a basic catalogue could be used in other seasons as well. Map type characteristics, i.e., following map types and persistence, may indicate significant departures from those for the summer, as would precipitation probabilities.

6.5 Map Types and Numerical Weather Prognoses

Tests with independent data in this chapter indicate that map typing and derived climatological aids, namely PoPs, show skill in forecasting. In order for the results of this study to be used in a forecast office, numerical weather prognoses (NWP) of 500 mb. and surface maps would be required to obtain corresponding map types, to forecast for tomorrow or longer because visual map typing is not reliable (section 3.6, Hartranft et al, 1970a).

With the cooperation of the Edmonton Weather Office, a test of the numerical weather prognoses was undertaken. Upper air and surface data were abstracted from 1:40 million scale facsimile charts of the six-layer NMC

primitive equations model. These prognoses were valid thirty-six hours (at 12Z) after the initial data time. The period used was from April 1, 1974 to July 31, 1974, a total of 112 surface forecasts and 116 500 mb. forecasts because of some missing or unreadable charts.

The forecast maps were correlated with the map catalogues and verification of the forecasts was carried out with the actual map types which developed. Although the primary and secondary map types were obtained, only the primary map types were verified. The results are indicated in Table 16.

TABLE 16

Forecast Map Type Verification Using Six-Layer Thirty-six Hour P.E. Prognosis

	500 mb.	Surface
Forecast Primary Verifies	43 (37%)	27 (24%)
Forecast Uncorrelated Verifies	8 (7%)	19 (16%)
Forecast Secondary Verifies as Actual Primary	22 (19%)	11 (10%)
Forecast Primary Incorrect	43 (37%)	55 (49%)

The most noticeable result is that the NWP is able to forecast the 500 mb. map type much better than the surface type. This result could be expected since there is greater variation and complexity in the surface pressure pattern and the degree of development of surface NWP. The forecast primary 500 mb. map types verify one and one-half times as often as that of the surface but the variation decreases when the correct uncorrelated map types are included. The uncorrelated group forecasts for the surface types are larger since this is the dominant group. There is some correspondence between the forecast and the actual map type for the third group in Table 16 since the forecast secondary verifies as the actual primary type. By combining the first three groups as being correct forecasts, the numerical prognoses indicate that fifty percent of the maps will verify correctly for the surface with better results for 500 mb.

The results are somewhat discouraging but it should be noted that the data sample was small and the thirty-six hour forecast period was relatively long. Further testing is definitely required not only to increase the data sample but to test the various forecast periods. It should be emphasized that only the forecast map types were verified. It may be that the forecast probability of precipitation verification will not be changed to a large degree even with the errors in the forecast type. This aspect needs to be investigated when a larger data sample is obtained.

All numerical weather prognoses produce errors under a variety of synoptic situations because of simplifying assumptions, unrealistic topographic modelling or data initialization. By comparing the forecast and actual map types, it may be possible to distinguish consistent errors in the prognosis, thereby

enabling forecast errors to be corrected, not only in the map types but also in the weather occurrence.

CHAPTER VII

SUMMARY AND CONCLUSIONS

7.1 Summary and Conclusions

This study has given a means of classifying synoptic maps for Alberta using the objective correlation method developed by Lund (1963) and later refined by the Map Typing Project Office, 12th Weather Squadron, Colorado Springs. Classification of 500 mb. flows for the summer period, May to September 1963-1971, has delineated thirty-five distinct map types (see the 500 mb. summer map catalogue, Appendix 4). Statistical information on occurrence and frequency, map types most frequently following and map type persistence are contained in the map catalogue. The 500 mb. catalogue can be used as a climatological forecast aid for predominant summer flow patterns and the occurrence of precipitation in Western Canada and the Northwestern United States.

A year-round surface map catalogue was also produced by the Map Typing Project Office, for Alberta and most of British Columbia. It used data covering a twenty-six year period (January to December, 1946-1971). Appendix 2 contains this catalogue of thirty-three distinct surface map patterns. Since the catalogue contains statistical information on map types for each month of the year, the seasonal change of weather systems is indicated.

Probabilities of twenty-four hour summer (06Z-06Z) precipitation for both 500 mb. and surface catalogue types have been derived and they illustrate the catalogues' application to precipitation forecasting. Four methods of analysis were employed for a threshold precipitation value of 0.01 inches (Appendices 5, 6, 7, 8). The results indicate that significant variation in precipitation probabilities are obtained with different map types or combinations of types. Skill scores indicate the best classification method and improvement over climatological forecasting. The best results were obtained for stations in southern Alberta; this is possibly related to topographic effects. In general, results indicate low skill scores because too many forecasts are made at the climatic frequency of precipitation. This implies that more parameters are required.

The derived probabilities of precipitation were verified for an independent data sample (May-September, 1972-1973) using the Brier Score. The forecast probabilities are highly reliable but low skill scores were obtained because there were too many forecasts near the climatological frequency of precipitation. Negative skill scores were obtained for many stations indicating the need for more research.

The derived precipitation probabilities were also verified for the same period (May - September, 1972-1973) using 18Z-18Z precipitation amounts rather than 06Z-06Z and the 00Z map type rather than the 12Z. Comparable results were obtained.

A higher precipitation threshold (0.10 inches instead of 0.01 inches) was considered in section 6.3 and concluded to be important in light of

a twenty-four hour precipitation period. Probabilities of twenty-four hour precipitation (0.10 inches or more) were therefore computed (Appendices 9, 10) and verified for 1972 and 1973. The results are comparable.

The results on precipitation probabilities are good considering that only two predictors, namely the 500 mb. and surface flows, are used. Although convective precipitation predominates during summer, no attempt was made to distinguish between the two types in these summer precipitation studies.

Two additional studies were carried out. The first consisted of obtaining map types for a winter period using the summer 500 mb. catalogue. Indications are that the 500 mb. catalogue types can be used in other seasons. The second study tested the ability of numerical weather prognoses to forecast the occurrence of the correct map type. The numerical prognoses forecast the occurrence of the correct type nearly fifty percent of the time. The 500 mb. flow is forecast correctly more often than the surface flow. With improved numerical prognoses, the forecast verifications should increase. It is surmised that consistent errors in the numerical prognoses during certain synoptic situations, could be revealed by map typing studies. This study has shown the usefulness of map types in the verification of NWP prognoses and is currently being implemented at the Edmonton Weather Office.

The use of the product moment correlation coefficient to classify weather maps was discussed in section 2.2.1. The major advantage of its use is that the classifications are determined solely by the orientation of pressure systems and, therefore, the directions of flow. It must be remembered that the

pressure and the pressure gradient at any location is not taken into account. These two factors will have a bearing on the weather phenomena being investigated. It would be advantageous to define subsets within a particular map type based on the magnitude and gradients of the weather system.

A further sophistication to map typing was presented by Paegle and Kierulff (1974). Besides 500 mb. typing they considered 850-500 mb. thicknesses, 500-300 mb. thickness, 500 mb. absolute geostrophic vorticities, thermal advections and vertical velocities. Their results indicate that a similar extension of this study would be extremely beneficial to our understanding of Western Canada weather systems.

The classification criterion used in this thesis guarantees that each map is placed within the most analogous type. In many cases, a particular map may be similar to two or more predetermined types. In such situations, future studies may find it advantageous to define "hybrid" types, provided that the duplicated classifications are numerous.

The classification scheme does not guarantee that any one map will resemble the 'key' map at all locations or grid points. Paegle and Kierulff (1974) found that variation of maps belonging to a catalogue type resulted in a significant categorizing of the atmospheric fields over most of the "window."

The derived precipitation probabilities indicated that improvement over forecasting by climatological probability is obtained by considering synoptic pressure patterns, a result well known by meteorologists. The relatively low skill scores obtained may be related to the twenty-four hour precipitation amounts which were used. The data base would

be used more effectively if the precipitation period were reduced to twelve hours. Precipitation studies could also be extended to account for different amounts, types, and seasons. The consideration of too many subgroups of precipitation events would, of course, develop statistical problems due to the finite nature of the data base. Some work on manually recognizing significant subgroups has been done in this study in section 5.3.2 and 6.2 and has given useful results.

Although this study has used map types to obtain probabilities of precipitation, there are a variety of other climatological aids which could also be produced. Examples include cloud amounts, ceiling and visibility tables and any other phenomena for which the synoptic flow pattern is the dominant influence.

The 500 mb. and surface map classifications obtained in this study provide a good addition to our knowledge of the weather systems in Western Canada. These map catalogues also provide a good foundation for the development of climatological or forecast aids of weather phenomena for which the synoptic flow pattern is the dominant factor.

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APPENDIX 1

SURFACE MAP TYPE AREA AND GRID POINT PRESSURE VALUES

The surface map typing window is illustrated in Figure 6, and consists of twenty-three NMC grid points (spacing 381 Km.). The window is outlined with a dashed line. The date and grid point pressure values for each map type are given in Table 17.

FIGURE 6. ALBERTA WINDOW
NUMBERED GRID POINTS REFER TO THE ORDER IN WHICH THE PRESSURE VALUES ARE LISTED IN TABLE (SEE BELOW).

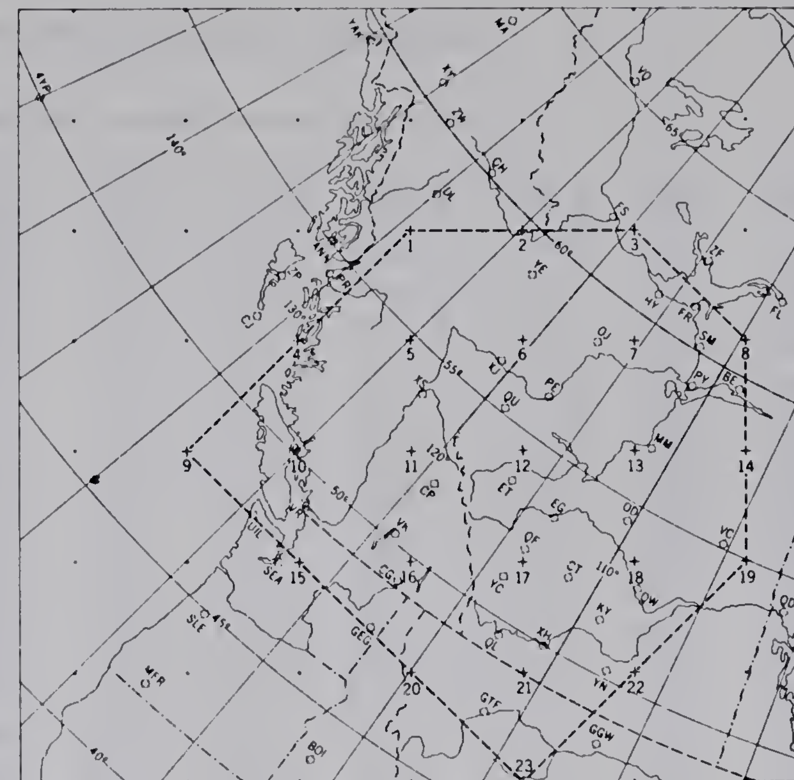


TABLE 17. GRID POINT PRESSURE VALUES

MAP TYPE	DATE	GRID POINT PRESSURE VALUES (MEAN SEA LEVEL)											
1	26 APR 54	1025.6	1032.3	1038.0	1016.4	1023.3	1032.9	1035.6	1035.9	1015.3	1013.6	1019.6	1029.3
		1032.9	1033.1	1014.0	1016.8	1023.3	1026.1	1026.8	1014.8	1017.9	1018.1	1014.6	
2	30 SEP 70	1013.2	1004.3	1001.2	1018.8	1014.0	1004.5	999.4	1001.0	1022.0	1022.7	1017.3	1009.8
		1004.3	1002.4	1024.8	1022.4	1014.5	1008.4	1006.6	1024.3	1016.2	1010.7	1019.4	
3	29 MAR 66	994.3	993.4	993.9	1003.6	1004.0	1001.5	999.8	1005.7	1014.5	1015.7	1014.9	1010.1
		1006.9	1010.5	1023.3	1021.4	1015.0	1013.0	1014.6	1023.8	1018.5	1017.1	1020.9	
4	10 MAY 59	1009.0	1003.4	1002.8	1015.7	1009.5	1002.3	998.6	1001.0	1021.1	1015.2	1008.9	1001.9
		996.6	996.2	1015.3	1008.9	1001.6	995.1	992.6	1008.9	1001.8	994.3	1002.0	
5	18 MAY 54	1010.7	1012.3	1014.3	1009.1	1012.0	1013.6	1016.7	1018.4	1011.5	1013.3	1014.9	1016.8
		1020.6	1021.8	1014.5	1015.0	1017.3	1021.7	1024.0	1014.2	1017.1	1022.0	1018.3	
6	5 OCT 70	1020.3	1026.9	1024.8	1016.1	1015.4	1022.8	1019.2	1011.0	1019.6	1011.3	1010.3	1014.8
		1011.7	1006.7	1009.1	1005.9	1005.5	1003.6	1000.5	1003.8	999.3	999.2	999.2	
7	17 NOV 67	1025.8	1022.7	1016.4	1024.0	1029.0	1023.6	1015.8	1008.3	1019.6	1025.3	1032.0	1025.4
		1012.8	1002.3	1026.2	1030.7	1025.9	1014.6	1000.5	1028.4	1025.4	1017.9	1024.3	
8	27 SEP 61	1022.6	1025.2	1024.6	1012.8	1022.4	1025.9	1025.7	1027.2	1013.4	1019.1	1025.8	1028.1
		1028.1	1027.8	1022.9	1028.2	1030.0	1029.6	1026.8	1028.5	1031.1	1030.1	1030.8	

TABLE 17 . GRID POINT PRESSURE VALUES (CONTINUED)

MAP TYPE	DATE	GRID POINT PRESSURE VALUES (MEAN SEA LEVEL)											
9	22 SEP 54	1002.8	996.0	994.6	1012.2	1006.3	997.6	995.7	1002.4	1015.5	1013.6	1008.2	1001.1
		1001.4	1008.3	1013.3	1009.6	1005.0	1005.9	1012.2	1009.8	1008.3	1008.7	1010.0	
10	6 MAR 58	1010.0	1014.0	1020.3	1011.4	1012.9	1017.6	1022.9	1024.3	1013.8	1010.9	1012.3	1018.0
		1023.0	1027.0	1010.5	1008.9	1013.8	1021.0	1029.1	1006.4	1010.0	1019.0	1006.9	
11	20 NOV 69	1007.3	1021.8	1026.6	999.2	1009.0	1021.6	1026.4	1028.3	1007.6	1011.3	1015.1	1018.8
		1023.3	1027.8	1021.5	1023.6	1018.3	1020.5	1027.6	1028.5	1018.7	1018.8	1021.6	
12	19 JUL 70	1011.1	1008.8	1007.7	1015.5	1011.5	1010.5	1012.8	1016.4	1018.0	1016.5	1014.3	1015.4
		1019.4	1021.7	1017.3	1016.6	1020.8	1025.5	1025.7	1016.3	1022.3	1027.0	1021.1	
13	10 JUL 60	1015.7	1014.9	1008.2	1014.6	1015.3	1013.0	1005.1	1002.0	1016.0	1015.0	1013.6	1012.4
		1008.6	1006.1	1013.7	1010.6	1010.6	1010.6	1008.8	1009.6	1010.0	1010.1	1010.0	
14	27 JUL 54	1021.6	1022.5	1022.7	1022.8	1019.5	1018.3	1020.1	1019.6	1025.9	1023.1	1018.6	1014.7
		1018.0	1020.3	1021.0	1018.0	1013.7	1015.6	1019.0	1016.1	1013.6	1013.9	1015.0	
15	22 DEC 63	1001.0	1009.0	1014.7	999.9	1007.8	1010.1	1013.3	1017.5	1006.7	1016.2	1017.3	1018.5
		1017.8	1021.8	1025.8	1030.8	1022.6	1026.1	1028.0	1031.5	1025.6	1028.1	1031.3	
16	6 DEC 58	1043.4	1048.0	1039.7	1027.1	1042.9	1045.7	1038.0	1031.8	1016.6	1021.0	1035.4	1043.9
		1040.6	1036.0	1020.1	1029.9	1039.8	1040.9	1037.8	1028.0	1037.9	1040.9	1034.5	
17	8 SEP 60	1023.0	1019.0	1016.5	1027.0	1026.2	1021.6	1017.5	1015.6	1024.3	1025.8	1027.2	1025.3
		1021.6	1019.8	1023.7	1028.8	1028.9	1024.9	1022.4	1029.1	1029.9	1026.0	1028.1	
18	24 JAN 60	1025.0	1030.0	1029.6	1015.0	1028.0	1027.5	1023.0	1019.0	1006.6	1011.9	1022.7	1022.9
		1020.4	1017.0	1015.7	1022.9	1021.1	1020.0	1018.1	1022.5	1017.9	1018.1	1019.5	
19	31 JAN 65	1020.8	1027.8	1032.5	1020.5	1020.8	1026.6	1029.4	1027.6	1025.1	1018.6	1016.5	1022.3
		1026.7	1023.5	1019.6	1013.5	1016.4	1021.1	1018.0	1011.0	1007.2	1008.5	997.7	
20	30 JAN 67	1010.0	1020.8	1024.0	1012.0	1014.5	1019.1	1021.8	1022.0	1017.0	1016.1	1014.3	1015.4
		1014.0	1015.1	1018.6	1011.6	1006.1	1002.8	1007.5	1014.1	1002.9	1000.4	1007.6	
21	15 FEB 65	999.4	1010.5	1020.3	1010.1	1006.1	1008.5	1015.1	1017.1	1019.5	1017.8	1011.1	1007.7
		1014.7	1020.8	1020.4	1015.4	1012.7	1019.5	1024.4	1019.7	1016.8	1022.4	1021.0	
22	16 FEB 65	1003.6	1010.1	1017.7	1007.6	1005.0	1006.6	1014.0	1017.5	1014.0	1014.1	1009.2	1004.0
		1010.5	1015.8	1020.2	1014.0	1006.3	1009.5	1012.9	1017.0	1009.5	1010.8	1015.8	
23	5 APR 57	1014.6	1017.9	1027.1	1017.0	1014.0	1015.7	1022.9	1029.5	1021.3	1017.0	1012.1	1012.9
		1018.8	1023.9	1015.3	1009.9	1010.0	1015.0	1017.7	1011.3	1009.0	1012.5	1013.0	
24	1[illegible] APR 57	1008.0	1013.0	1017.0	1008.0	1008.0	1012.0	1016.9	1022.7	1013.5	1011.0	1010.2	1010.9
		1014.3	1018.9	1016.5	1013.9	1009.9	1011.0	1014.7	1015.1	1007.9	1008.3	1010.4	
25	24 JUN 56	1014.4	1007.9	1009.1	1019.1	1015.0	1011.3	1011.9	1017.3	1022.3	1018.9	1015.0	1013.9
		1014.0	1019.0	1017.5	1012.0	1010.1	1011.9	1017.6	1010.3	1006.9	1011.8	1008.0	
26	28 AUG 57	1019.8	1015.0	1010.9	1021.1	1020.9	1018.2	1015.9	1015.3	1020.7	1020.0	1021.0	1020.9
		1021.5	1021.9	1019.5	1021.0	1022.3	1024.0	1023.8	1018.6	1021.0	1023.2	1019.1	
27	29 AUG 67	1019.7	1024.8	1025.6	1017.0	1021.2	1025.8	1028.2	1029.3	1018.1	1016.8	1021.1	1027.5
		1028.0	1026.8	1016.6	1021.8	1027.3	1026.3	1023.7	1021.0	1025.9	1027.1	1024.0	
28	21 SEP 60	1022.3	1021.6	1021.9	1026.1	1025.8	1024.3	1024.0	1021.6	1029.6	1028.4	1026.7	1025.0
		1024.3	1021.6	1028.8	1027.5	1025.8	1024.3	1018.0	1027.0	1026.5	1024.4	1024.6	
29	11 OCT 55	997.6	1001.9	1002.3	998.6	1005.9	1005.3	1001.9	1004.5	1007.3	1010.9	1012.5	1008.9
		1003.5	1000.9	1018.6	1017.0	1011.5	1004.9	1000.0	1017.5	1010.9	1002.5	1007.7	
30	15 NOV 59	1040.5	1043.9	1038.9	1029.2	1040.9	1041.9	1036.0	1031.7	1018.8	1025.0	1034.0	1037.0
		1032.9	1027.9	1017.4	1026.0	1032.2	1029.0	1023.8	1018.3	1028.0	1023.1	1015.1	
31	21 NOV 69	1001.8	1010.1	1015.0	1011.3	1003.8	1005.6	1008.5	1008.8	1018.1	1015.5	1009.8	1004.6
		1003.4	1005.5	1019.9	1016.8	1007.6	1002.3	1005.0	1019.0	1008.6	1004.3	1012.0	
32	9 NOV 70	1012.5	1021.3	1023.5	1008.1	1011.0	1019.1	1021.5	1018.8	1013.1	1009.5	1010.0	1015.0
		1016.4	1015.3	1012.8	1012.5	1012.5	1011.5	1013.5	1015.3	1011.3	1011.0	1014.5	
33	3 DEC 54	989.5	997.3	1008.3	1001.5	1000.0	999.7	1003.9	1005.0	1013.0	1014.3	1009.6	1002.0
		1002.6	1005.0	1017.0	1012.7	1003.9	1003.5	1006.6	1016.1	1009.6	1006.8	1015.2	

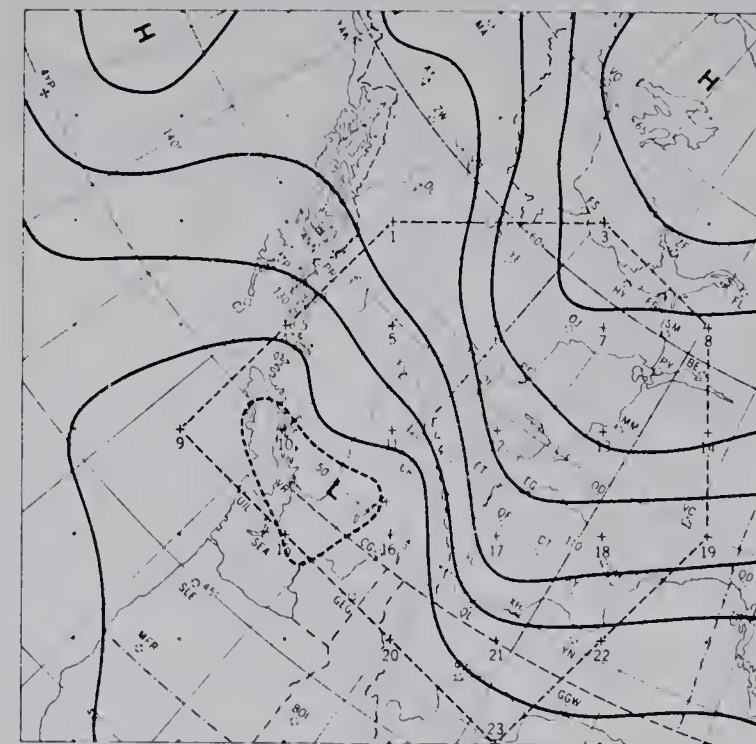
APPENDIX 2

SURFACE MAP TYPES AND CHARACTERISTICS

The surface pressure maps in this Appendix represent the pressure patterns associated with the map types. The window is in the center of the map, and is outlined with a dashed line. The characteristics of each map type are summarized by month. The number of occurrences indicates the number of times the pressure pattern occurred during each month for the entire period of record (1946-1971). The frequency of occurrences gives the percentage of time that the map type occurred during the month. The next set of data indicates the map types which most frequently followed the given type and the corresponding percentage. Finally, the duration of the map type is indicated by the number of twelve hour periods that the map type persisted, and the corresponding percentage.

****
* MAP TYPE 1 *
****

ALBERTA WINDOW
****
PERIOD OF RECORD
1946-1971
****
THIS TYPE
OCCURRED 815 TIMES
DURING THE PERIOD
OF RECORD

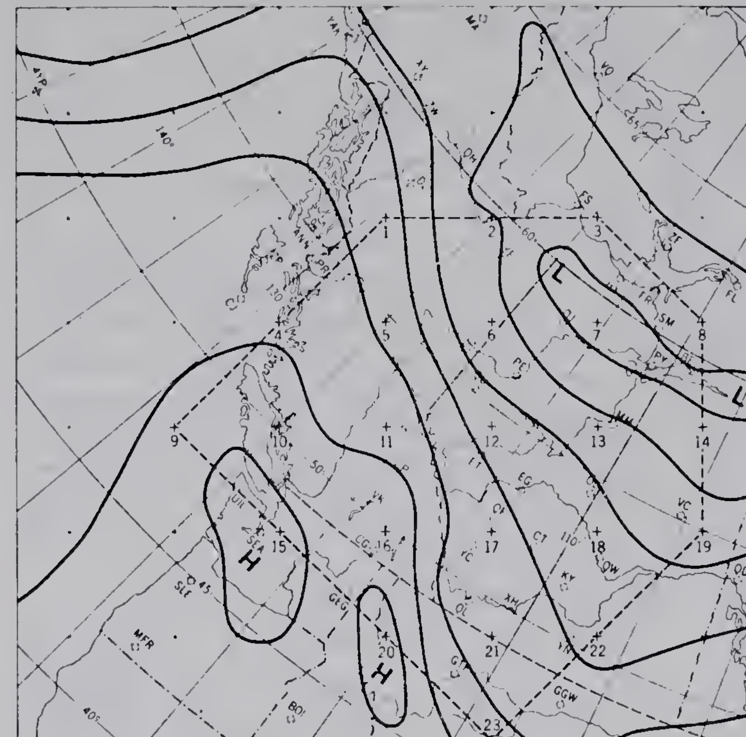


CHARACTERISTICS

MONTH	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
NUMBER OF OCCURRENCES	136	108	118	100	56	28	20	23	34	34	64	94
FREQUENCIES OF OCCURRENCES	11	10	10	8	5	2	2	2	3	3	5	7
MAP TYPE MOST	1/ 47	1/ 53	1/ 49	1/ 64	1/ 47	1/ 31	1/ 40	1/ 25	1/ 35	1/ 52	1/ 47	1/ 54
FREQUENTLY	27/ 25	27/ 18	27/ 20	10/ 14	10/ 19	U/ 25	10/ 20	10/ 19	10/ 15	27/ 20	27/ 13	16/ 8
FOLLOWING	16/ 8	10/ 5	10/ 13	U/ 12	27/ 14	10/ 19	27/ 13	19/ 19	U/ 15	8/ 8	19/ 6	27/ 8
(MAP TYPE/	U/ 8	16/ 5	U/ 8	27/ 8	23/ 7	16/ 6	U/ 13	U/ 19	19/ 12	10/ 4	30/ 6	30/ 7
FREQUENCY)	30/ 5	19/ 5	32/ 4	23/ 2	U/ 7	19/ 6	23/ 7	23/ 13	27/ 8	11/ 4	U/ 6	U/ 7
MOST FREQUENT	1/ 53	1/ 45	1/ 43	1/ 29	1/ 55	1/ 55	1/ 44	1/ 83	1/ 65	1/ 36	1/ 48	1/ 58
DURATION (NUMBER	2/ 23	2/ 30	2/ 31	2/ 29	2/ 25	2/ 45	2/ 44	2/ 8	2/ 18	2/ 27	2/ 30	2/ 26
OF 12HR PERIODS/	4/ 13	3/ 12	3/ 20	3/ 24	3/ 10		3/ 11	4/ 8	3/ 18	3/ 18	3/ 13	4/ 6
FREQUENCY	3/ 9	4/ 3	4/ 3	4/ 10	4/ 5					4/ 18	5/ 9	5/ 6

****
* MAP TYPE 2 *
****

ALBERTA WINDOW
****
PERIOD OF RECORD
1946-1971
****
THIS TYPE
OCCURRED 1157 TIMES
DURING THE PERIOD
OF RECORD

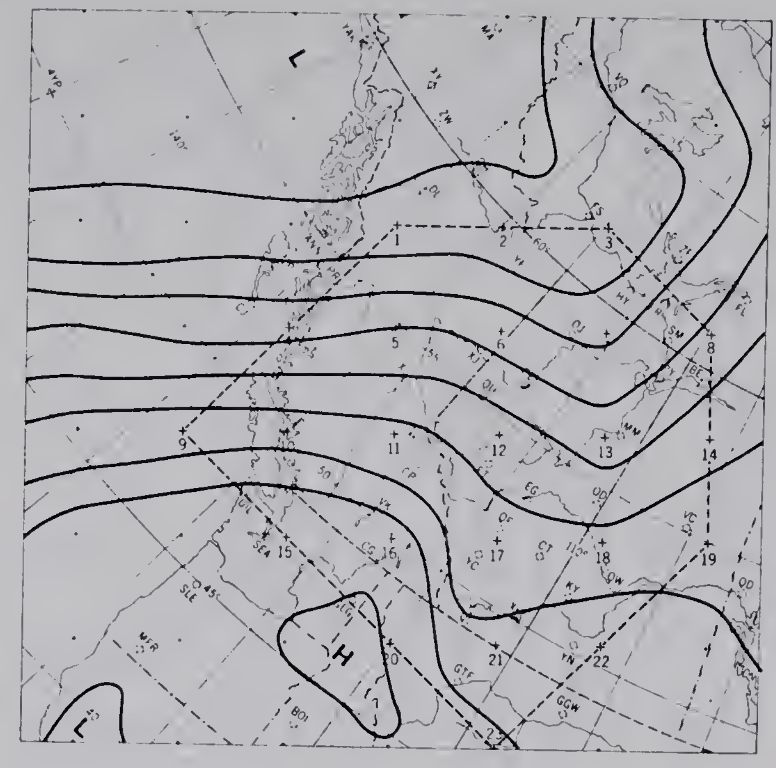


CHARACTERISTICS

MONTH	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
NUMBER OF OCCURRENCES	64	70	61	59	58	117	134	121	120	153	106	94
FREQUENCIES OF OCCURRENCES	5	6	5	5	5	10	11	10	10	13	9	7
MAP TYPE MOST FREQUENTLY FOLLOWING (MAP TYPE/ FREQUENCY)	2/ 41 4/ 15 31/ 10 U/ 10 3/ 5	2/ 48 4/ 17 3/ 10 U/ 10 29/ 4	2/ 33 4/ 29 U/ 19 3/ 5 33/ 5	4/ 27 2/ 24 U/ 20 33/ 7 3/ 5	2/ 38 4/ 31 U/ 17 9/ 7 3/ 2	2/ 48 4/ 22 U/ 9 13/ 6 3/ 5	2/ 46 4/ 18 13/ 10 U/ 9 17/ 6	2/ 51 4/ 12 13/ 12 U/ 9 17/ 7	2/ 43 4/ 16 13/ 11 17/ 6 U/ 6	2/ 41 4/ 21 U/ 10 3/ 9 7/ 4	2/ 39 4/ 16 7/ 12 3/ 9 U/ 7	2/ 39 4/ 18 7/ 9 3/ 7 29/ 7
MOST FREQUENT DURATION (NUMBER OF 12HR PERIODS/ FREQUENCY	1/ 57 2/ 22 3/ 17 4/ 4	1/ 52 2/ 28 3/ 8 4/ 8	1/ 65 2/ 23 3/ 8 4/ 4	1/ 73 2/ 20 3/ 7	1/ 58 2/ 31 4/ 8 3/ 4	1/ 59 2/ 20 3/ 10 5/ 7	1/ 54 2/ 31 3/ 8 4/ 2	1/ 45 2/ 21 3/ 21 4/ 9	1/ 58 2/ 21 3/ 12 4/ 9	1/ 60 2/ 25 3/ 11 4/ 4	1/ 64 2/ 20 4/ 9 3/ 7	1/ 68 2/ 16 3/ 8 4/ 5

****
* MAP TYPE 3 *
****

ALBERTA WINDOW
****
PERIOD OF RECORD
1946-1971
****
THIS TYPE
OCCURRED 658 TIMES
DURING THE PERIOD
OF RECORD

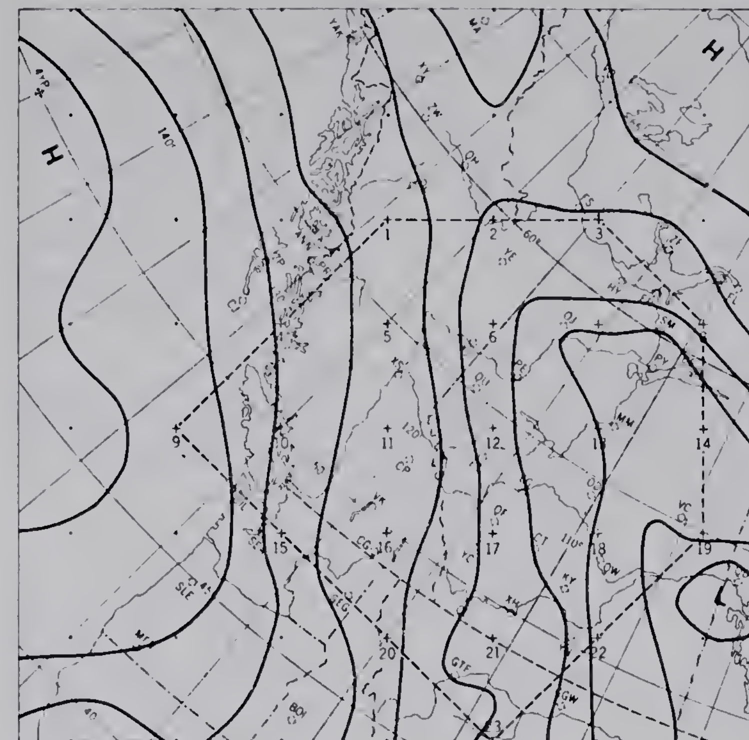


CHARACTERISTICS

MONTH	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
NUMBER OF OCCURRENCES	36	47	46	55	24	20	11	22	74	152	100	71
FREQUENCIES OF OCCURRENCES	3	4	4	5	2	2	1	2	6	12	8	6
MAP TYPE MOST FREQUENTLY FOLLOWING (MAP TYPE/ FREQUENCY)	2/ 45 3/ 25 17/ 10 9/ 5 15/ 5	2/ 32 3/ 29 4/ 10 9/ 10 15/ 6	3/ 32 2/ 21 9/ 11 15/ 11 17/ 7	3/ 45 2/ 18 9/ 18 U/ 9 12/ 3	3/ 31 9/ 31 U/ 19 2/ 13 33/ 6	9/ 29 2/ 21 3/ 21 15/ 14 17/ 7	2/ 33 3/ 33 9/ 33	3/ 36 9/ 36 12/ 14 2/ 7 U/ 7	2/ 26 3/ 26 9/ 24 U/ 11 12/ 5	3/ 33 2/ 28 9/ 13 17/ 8 15/ 7	3/ 34 2/ 29 15/ 11 9/ 6 U/ 6	3/ 34 2/ 32 15/ 13 33/ 6 U/ 6
MOST FREQUENT DURATION (NUMBER OF 12HR PERIODS/ FREQUENCY	1/ 71 2/ 21 3/ 7	1/ 68 2/ 23 3/ 9	1/ 58 2/ 37 3/ 5	1/ 53 3/ 24 2/ 18 5/ 6	1/ 64 2/ 27 3/ 9	1/ 73 2/ 27	1/ 50 2/ 50	1/ 67 3/ 22 2/ 11	1/ 75 2/ 18 3/ 7	1/ 69 2/ 17 3/ 11 4/ 3	1/ 68 2/ 20 4/ 7 3/ 5	1/ 72 2/ 24 3/ 3

****
* MAP TYPE 4 *
****

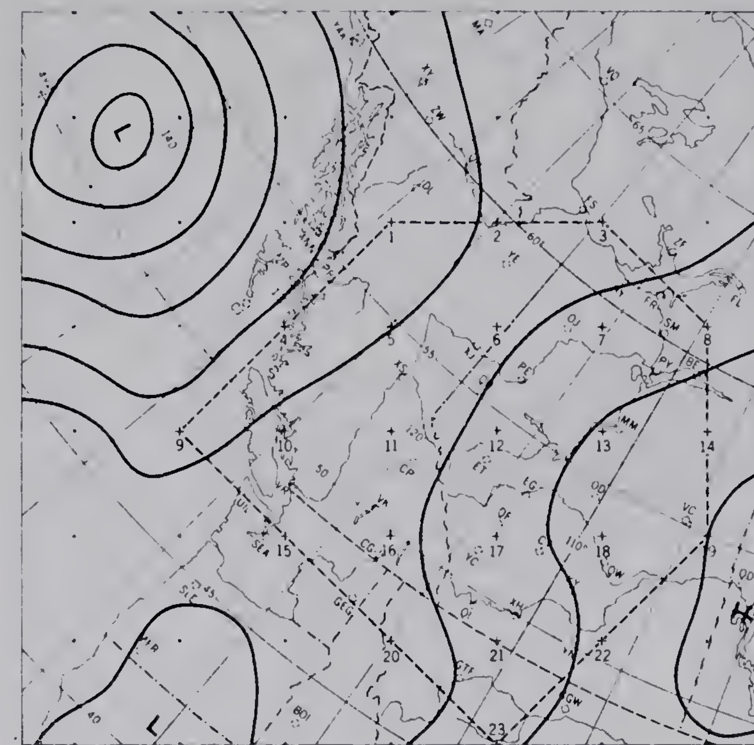
ALBERTA WINDOW
****
PERIOD OF RECORD
1946-1971
****
THIS TYPE
OCCURRED 1182 TIMES
DURING THE PERIOD
OF RECORD



CHARACTERISTICS

MONTH	JAN	FEB	MAR	APR	MAY	JUN
NUMBER OF OCCURRENCES	39	53	56	81	144	177
FREQUENCIES OF OCCURRENCES	3	5	5	7	12	15
MAP TYPE MOST FREQUENTLY FOLLOWING (MAP TYPE/ FREQUENCY)	U/ 38 4/ 21 2/ 17 6/ 8 28/ 4	4/ 37 U/ 20 2/ 15 6/ 5 14/ 5	4/ 42 U/ 21 2/ 12 28/ 7 31/ 7	4/ 36 U/ 19 2/ 6 7/ 6 14/ 6	4/ 55 U/ 19 2/ 7 7/ 5 14/ 4	4/ 56 2/ 14 U/ 14 7/ 3 9/ 3
MOST FREQUENT DURATION (NUMBER OF 12HR PERIODS/ FREQUENCY	1/ 82 2/ 18	1/ 48 2/ 44 3/ 8	1/ 68 2/ 16 3/ 8 5/ 4	1/ 61 2/ 33 3/ 3 6/ 3	1/ 40 2/ 33 4/ 13 3/ 11	1/ 37 2/ 27 3/ 22 4/ 8

MONTH	JUL	AUG	SEP	OCT	NOV	DEC
NUMBER OF OCCURRENCES	205	136	87	93	64	47
FREQUENCIES OF OCCURRENCES	16	11	7	8	5	4
MAP TYPE MOST FREQUENTLY FOLLOWING (MAP TYPE/ FREQUENCY)	4/ 53 2/ 17 U/ 16 13/ 5 7/ 4	4/ 44 U/ 23 2/ 8 7/ 7 13/ 7	4/ 40 28/ 15 U/ 14 2/ 9 6/ 8	4/ 36 U/ 16 7/ 10 28/ 9 2/ 7	4/ 25 U/ 20 2/ 15 6/ 10 7/ 8	4/ 28 U/ 19 7/ 13 29/ 13 3/ 9
MOST FREQUENT DURATION (NUMBER OF 12HR PERIODS/ FREQUENCY	1/ 46 2/ 23 3/ 17 4/ 9	1/ 46 2/ 37 3/ 11 4/ 5	1/ 47 2/ 37 3/ 16	1/ 57 2/ 36 4/ 5 3/ 2	1/ 65 2/ 31 3/ 4	1/ 68 2/ 23 3/ 9



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***************
* MAP TYPE  5 *
***************
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ALBERTA WINDOW

****

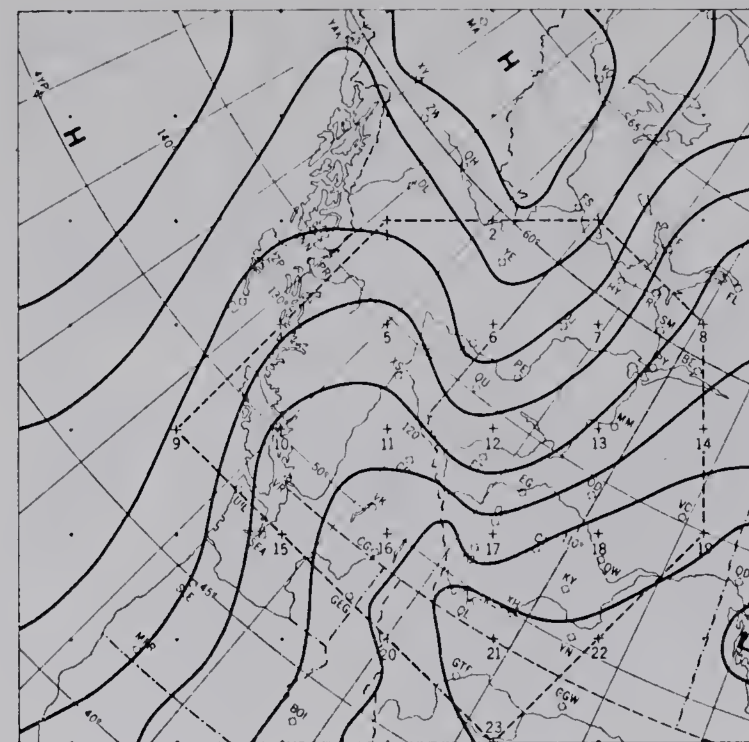
PERIOD OF RECORD
1946-1971

****

THIS TYPE
OCCURRED 428 TIMES
DURING THE PERIOD
OF RECORD

CHARACTERISTICS

MONTH	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
NUMBER OF OCCURRENCES	41	54	68	44	37	17	9	15	41	26	30	46
FREQUENCIES OF OCCURRENCES	3	5	6	4	3	1	1	1	3	2	2	4
MAP TYPE MOST	5/ 43	5/ 56	5/ 34	5/ 33	5/ 35	U/ 57	U/ 57	5/ 40	5/ 45	U/ 26	U/ 35	5/ 31
FREQUENTLY	11/ 16	U/ 16	21/ 15	U/ 29	U/ 30	5/ 29	12/ 29	12/ 30	U/ 14	12/ 21	5/ 26	U/ 31
FOLLOWING	8/ 14	8/ 5	U/ 13	12/ 19	12/ 20	12/ 14	5/ 14	10/ 10	8/ 10	15/ 21	15/ 17	10/ 11
(MAP TYPE/	U/ 8	10/ 5	11/ 11	8/ 10	9/ 10			22/ 10	12/ 10	5/ 16	8/ 9	15/ 11
FREQUENCY)	12/ 5	15/ 5	10/ 9	10/ 5	21/ 5			U/ 10	10/ 7	21/ 11	10/ 4	11/ 6
MOST FREQUENT	1/ 65	1/ 42	1/ 65	1/ 67	1/ 62	1/ 75	1/ 83	1/ 75	1/ 63	1/ 81	1/ 67	1/ 65
DURATION (NUMBER	2/ 15	2/ 26	2/ 23	2/ 25	2/ 31	2/ 25	2/ 17	2/ 25	2/ 19	2/ 19	2/ 27	2/ 22
OF 12HR PERIODS/	4/ 10	3/ 11	3/ 10	3/ 8	4/ 8				3/ 6		3/ 7	3/ 13
FREQUENCY	3/ 5	4/ 11	4/ 3						4/ 6			



****
* MAP TYPE 6 *
****

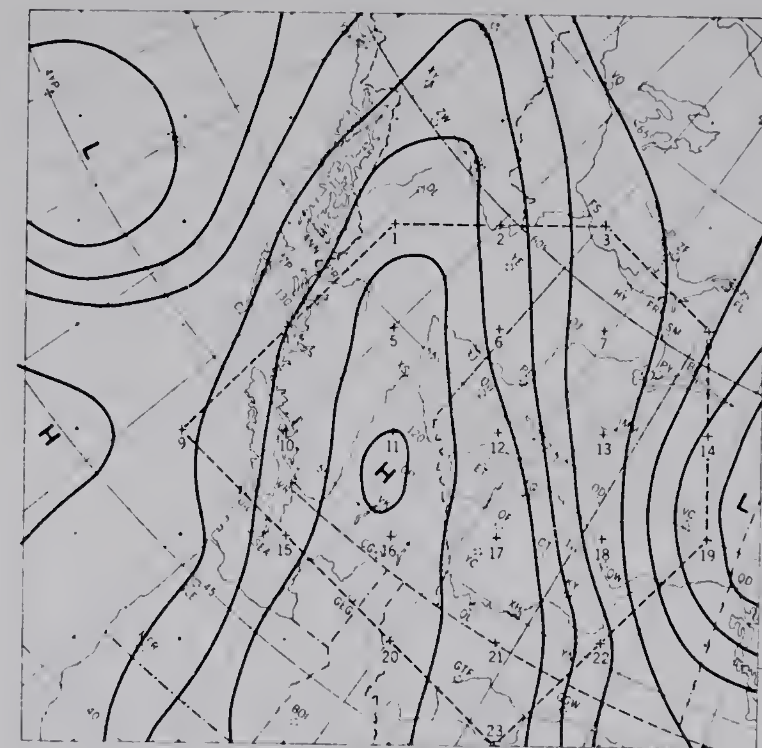
ALBERTA WINDOW
****
PERIOD OF RECORD
1946-1971
****
THIS TYPE
OCCURRED 281 TIMES
DURING THE PERIOD
OF RECORD

CHARACTERISTICS

MONTH	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
NUMBER OF OCCURRENCES	18	11	11	27	31	20	24	23	47	18	27	24
FREQUENCIES OF OCCURRENCES	1	1	1	2	3	2	2	2	4	1	2	2
MAP TYPE MOST FREQUENTLY FOLLOWING (MAP TYPE/ FREQUENCY)	30/ 27 U/ 27 1/ 18 6/ 18 19/ 9	U/ 30 1/ 20 30/ 20 6/ 10 7/ 10	U/ 43 6/ 14 11/ 14 19/ 14 20/ 14	6/ 38 19/ 19 U/ 19 1/ 6 25/ 6	U/ 35 6/ 24 19/ 18 1/ 6 4/ 6	19/ 33 U/ 33 20/ 17 1/ 8 6/ 8	U/ 60 6/ 27 14/ 7 19/ 7	U/ 45 30/ 18 6/ 9 19/ 9 23/ 9	6/ 33 30/ 33 U/ 22 1/ 3 19/ 3	6/ 60 30/ 20 1/ 10 U/ 10	U/ 37 6/ 26 30/ 21 1/ 5 19/ 5	6/ 29 30/ 29 U/ 29 16/ 10 19/ 5
MOST FREQUENT DURATION (NUMBER OF 12HR PERIODS/ FREQUENCY	1/ 78 2/ 22	1/ 89 2/ 11	1/ 80 2/ 20	1/ 50 2/ 40 3/ 10	1/ 77 2/ 15 3/ 8	1/ 91 2/ 9	1/ 80 2/ 20	1/ 90 2/ 10	1/ 71 2/ 13 3/ 13 4/ 4	3/ 50 1/ 25 2/ 25	1/ 64 2/ 36	1/ 60 2/ 40

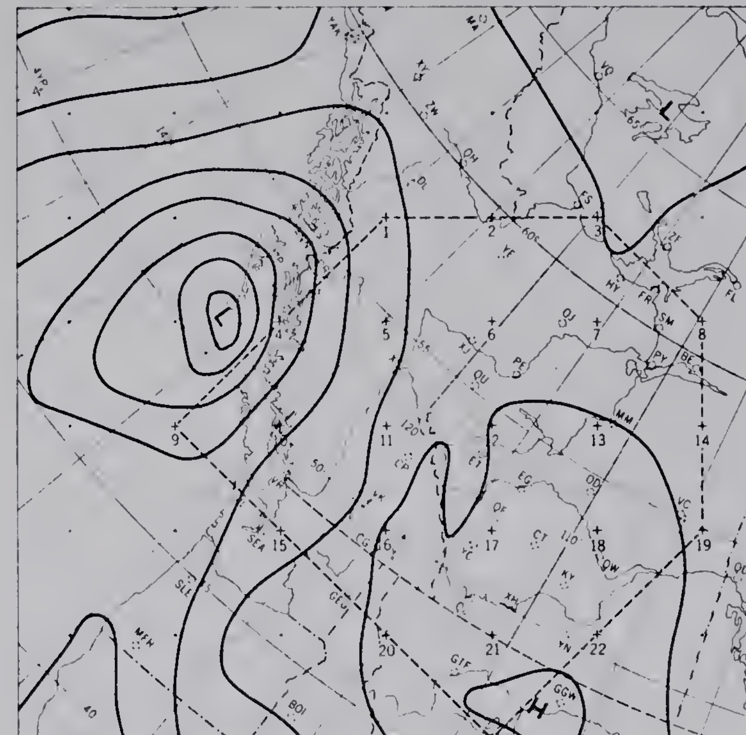
****
* MAP TYPE 7 *
****

ALBERTA WINDOW
****
PERIOD OF RECORD
1946-1971
****
THIS TYPE
OCCURRED 257 TIMES
DURING THE PERIOD
OF RECORD



CHARACTERISTICS

MONTH	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
NUMBER OF OCCURRENCES	18	9	4	14	10	15	35	34	41	30	31	16
FREQUENCIES OF OCCURRENCES	1	1	0	1	1	1	3	3	3	2	3	1
MAP TYPE MOST FREQUENTLY FOLLOWING (MAP TYPE/ FREQUENCY)	7/ 46 U/ 23 2/ 8 4/ 8 18/ 8	U/ 80 4/ 20	U/100	U/ 38 4/ 25 3/ 13 7/ 13 15/ 13	U/ 43 2/ 29 13/ 14 29/ 14	U/ 78 1/ 11 7/ 11	U/ 41 7/ 24 4/ 12 2/ 6 13/ 6	U/ 50 7/ 18 2/ 9 4/ 9 17/ 5	U/ 42 7/ 25 4/ 8 6/ 4 12/ 4	U/ 50 15/ 10 17/ 10 29/ 10 2/ 5	U/ 40 7/ 20 3/ 15 15/ 10 2/ 5	U/ 33 8/ 17 2/ 8 9/ 8 15/ 8
MOST FREQUENT DURATION (NUMBER OF 12HR PERIODS/ FREQUENCY	1/ 71 2/ 14 6/ 14	1/100	1/100	1/ 83 2/ 17	1/100	1/ 88 2/ 13	1/ 77 2/ 15 3/ 8	1/ 81 2/ 19	1/ 78 2/ 17 4/ 6	1/100	1/ 75 2/ 25	1/100



* MAP TYPE 8 *

ALBERTA WINDOW

****

PERIOD OF RECORD
1946-1971

****

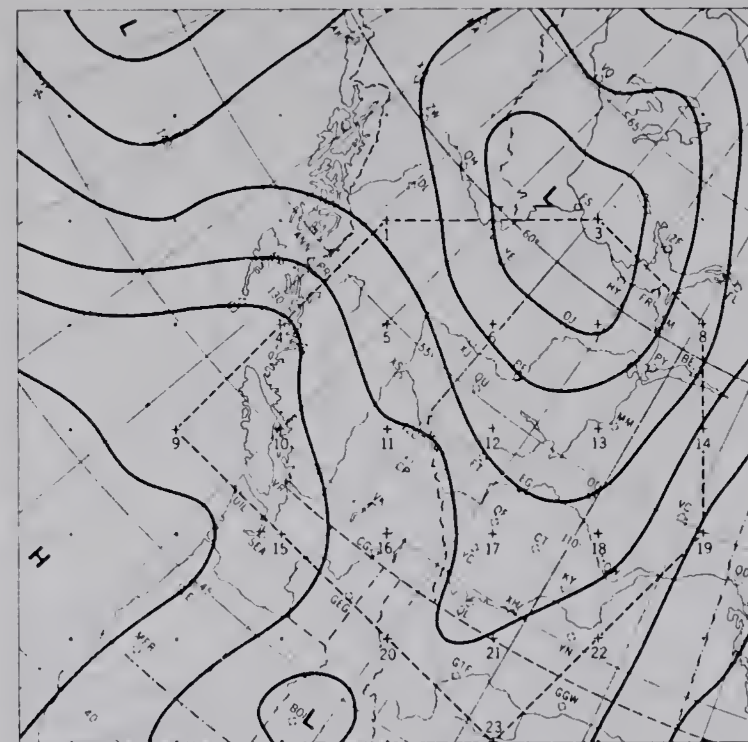
THIS TYPE
OCCURRED 282 TIMES
DURING THE PERIOD
OF RECORD

CHARACTERISTICS

MONTH	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
NUMBER OF OCCURRENCES	31	38	21	12	4	4	3	5	13	42	60	49
FREQUENCIES OF OCCURRENCES	3	3	2	1	0	0	0	0	1	3	5	4
MAP TYPE MOST FREQUENTLY FOLLOWING (MAP TYPE/ FREQUENCY)	8/ 30 11/ 20 5/ 15 U/ 15 1/ 5	8/ 41 U/ 17 11/ 14 5/ 10 15/ 7	5/ 27 11/ 27 27/ 27 8/ 13 U/ 7	5/ 14 8/ 14 11/ 14 12/ 14 15/ 14		5/ 33 12/ 33 15/ 33	U/100	12/100	5/ 43 11/ 29 3/ 14 27/ 14	8/ 26 15/ 19 U/ 15 5/ 11 27/ 11	8/ 37 11/ 20 5/ 15 U/ 10 27/ 7	8/ 37 5/ 16 11/ 13 15/ 11 U/ 11
MOST FREQUENT DURATION (NUMBER OF 12HR PERIODS/ FREQUENCY	1/ 62 2/ 31 3/ 8	1/ 50 2/ 38 3/ 13	1/ 85 2/ 15	1/ 83 2/ 17		1/100	1/100	1/100	1/100	1/ 80 2/ 10 3/ 10	1/ 73 2/ 15 3/ 8 8/ 4	1/ 63 2/ 21 3/ 13 4/ 4

****
* MAP TYPE 9 *
****

ALBERTA WINDOW
****
PERIOD OF RECORD
1946-1971
****
THIS TYPE
OCCURRED 545 TIMES
DURING THE PERIOD
OF RECORD

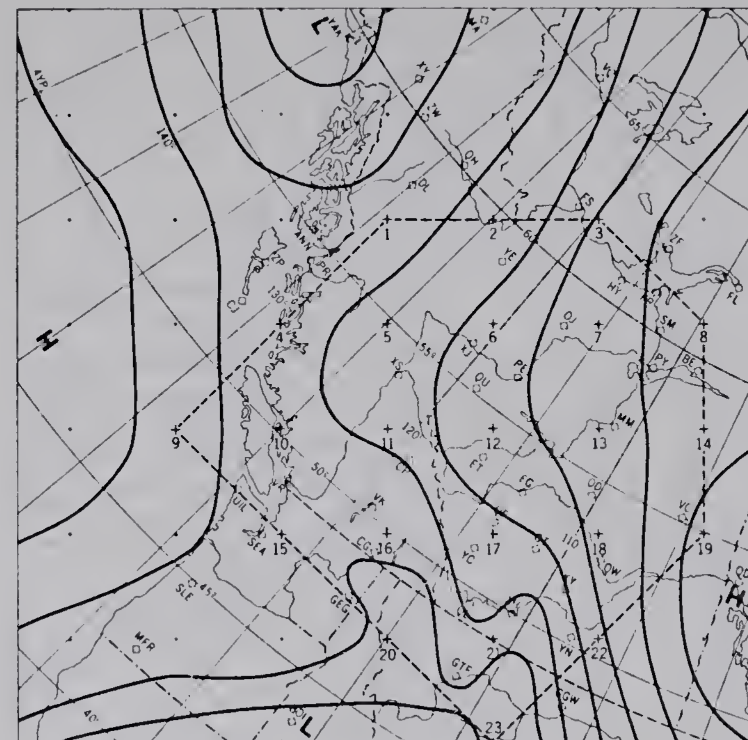


CHARACTERISTICS

MONTH	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
NUMBER OF OCCURRENCES	11	22	31	64	72	71	57	77	47	48	27	18
FREQUENCIES OF OCCURRENCES	1	2	3	5	6	6	5	6	4	4	2	1
MAP TYPE MOST FREQUENTLY FOLLOWING (MAP TYPE/ FREQUENCY)	2/ 38 3/ 25 4/ 25 U/ 13	2/ 33 33/ 25 U/ 25 4/ 17	2/ 38 9/ 25 4/ 13 U/ 13 7/ 4	2/ 35 9/ 23 4/ 17 U/ 13 3/ 4	9/ 35 U/ 22 2/ 20 4/ 7 3/ 4	2/ 33 9/ 33 U/ 15 4/ 13 3/ 2	2/ 27 4/ 24 9/ 24 U/ 17 3/ 2	9/ 30 2/ 23 U/ 18 4/ 14 13/ 7	2/ 36 U/ 28 9/ 17 3/ 6 4/ 6	2/ 31 9/ 22 4/ 19 29/ 8 U/ 8	2/ 50 4/ 15 9/ 15 14/ 5 15/ 5	2/ 57 3/ 7 4/ 7 9/ 7 13/ 7
MOST FREQUENT DURATION (NUMBER OF 12HR PERIODS/ FREQUENCY	1/100	1/100	1/ 72 2/ 22 3/ 6	1/ 74 2/ 20 3/ 6	1/ 69 2/ 20 3/ 6 4/ 3	1/ 70 2/ 17 3/ 13	1/ 80 2/ 13 3/ 3 4/ 3	1/ 67 2/ 26 3/ 5 4/ 3	1/ 79 2/ 21	1/ 81 2/ 15 3/ 4	1/ 82 2/ 18	1/ 92 2/ 8

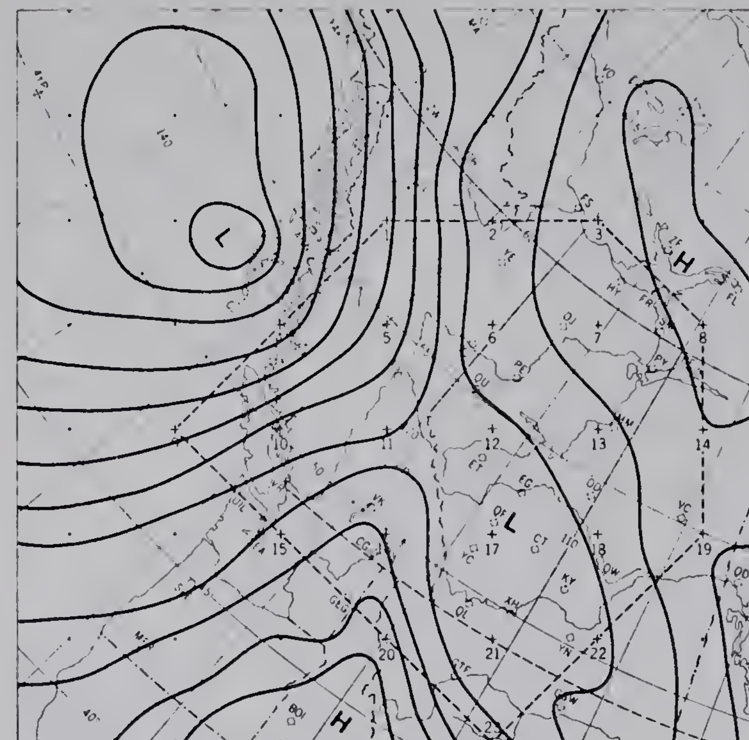
****
* MAP TYPE 10 *
****

ALBERTA WINDOW
****
PERIOD OF RECORD
1946-1971
****
THIS TYPE
OCCURRED 346 TIMES
DURING THE PERIOD
OF RECORD



CHARACTERISTICS

MONTH	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
NUMBER OF OCCURRENCES	22	41	56	47	48	31	17	24	27	4	15	14
FREQUENCIES OF OCCURRENCES	2	4	5	4	4	3	1	2	2	0	1	1
MAP TYPE MOST FREQUENTLY FOLLOWING (MAP TYPE/ FREQUENCY)	10/ 18 11/ 18 U/ 18 1/ 12 5/ 12	10/ 33 U/ 26 5/ 11 1/ 7 21/ 7	10/ 38 1/ 13 U/ 13 5/ 8 15/ 5	10/ 44 U/ 17 23/ 8 5/ 6 12/ 6	10/ 40 1/ 20 U/ 20 5/ 3 11/ 3	10/ 48 U/ 33 1/ 5 5/ 5 12/ 5	U/ 50 10/ 30 25/ 20	U/ 45 10/ 18 12/ 18 9/ 9 25/ 9	10/ 39 5/ 28 U/ 28 1/ 6	10/ 25 11/ 25 12/ 25 U/ 25	10/ 42 U/ 25 11/ 17 5/ 8 24/ 8	5/ 22 10/ 22 11/ 22 U/ 22 19/ 11
MOST FREQUENT DURATION (NUMBER OF 12HR PERIODS/ FREQUENCY	1/ 86 2/ 14	1/ 65 2/ 18 3/ 18	1/ 75 2/ 17 5/ 4 8/ 4	1/ 55 2/ 20 3/ 15 4/ 10	1/ 67 2/ 20 3/ 7 4/ 7	1/ 67 2/ 11 3/ 1 4/ 11	1/ 57 2/ 43	1/ 78 2/ 22	1/ 64 3/ 27 2/ 9	1/ 67 2/ 33	1/ 71 2/ 14 5/ 14	1/ 86 2/ 14



****
* MAP TYPE 11 *
****

ALBERTA WINDOW
****
PERIOD OF RECORD
1946-1971
****
THIS TYPE
OCCURRED 419 TIMES
DURING THE PERIOD
OF RECORD

CHARACTERISTICS

MONTH	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
NUMBER OF OCCURRENCES	77	65	65	16	11	4	1	1	13	25	63	78
FREQUENCIES OF OCCURRENCES	6	6	5	1	1	0	0	0	1	2	5	6
MAP TYPE MOST FREQUENTLY FOLLOWING (MAP TYPE/ FREQUENCY)	11/ 42 U/ 18 32/ 8 1/ 7 5/ 7	11/ 32 21/ 14 32/ 14 U/ 14 8/ 7	11/ 32 U/ 15 5/ 9 27/ 9 1/ 7	24/ 25 5/ 13 10/ 13 11/ 13 15/ 13	10/ 40 U/ 40 24/ 20	U/ 50 5/ 25 24/ 25	U/100		U/ 33 5/ 25 32/ 17 11/ 8 22/ 8	11/ 33 5/ 17 U/ 17 23/ 11 10/ 6	11/ 38 U/ 15 32/ 8 10/ 6 22/ 6	11/ 38 1/ 11 U/ 11 15/ 9 5/ 7
MOST FREQUENT DURATION (NUMBER OF 12HR PERIODS/ FREQUENCY	1/ 67 2/ 18 4/ 9 5/ 6	1/ 74 2/ 11 3/ 11 4/ 5	1/ 75 2/ 16 3/ 9	1/ 86 2/ 14	1/100	1/100	1/100		1/ 91 2/ 9	1/ 55 2/ 36 3/ 9	1/ 69 2/ 14 3/ 10 4/ 3	1/ 73 2/ 12 3/ 6 4/ 3

****
* MAP TYPE 12 *
****

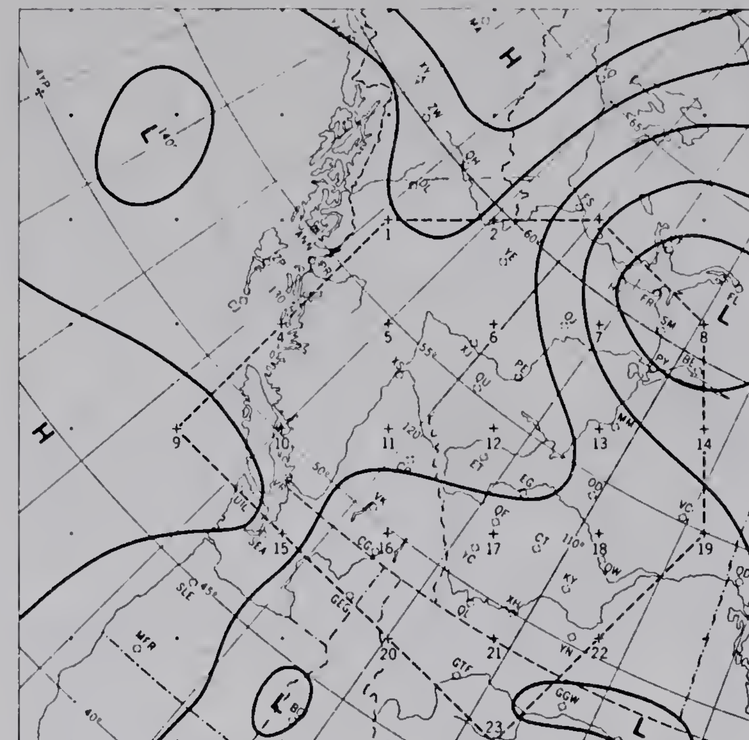
ALBERTA WINDOW
****
PERIOD OF RECORD
1946-1971
****
THIS TYPE
OCCURRED 273 TIMES
DURING THE PERIOD
OF RECORD

CHARACTERISTICS

MONTH	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
NUMBER OF OCCURRENCES	7	5	14	43	33	26	24	42	35	24	9	11
FREQUENCIES OF OCCURRENCES	1	0	1	4	3	2	2	3	3	2	1	1
MAP TYPE MOST FREQUENTLY FOLLOWING (MAP TYPE/ FREQUENCY)	5/ 50 3/ 25 U/ 25	U/100	2/ 17 3/ 17 9/ 17 26/ 17 33/ 17	12/ 41 9/ 29 U/ 18 26/ 6 5/ 3	12/ 35 U/ 35 9/ 19 3/ 4 21/ 4	9/ 39 12/ 33 U/ 17 26/ 11	9/ 33 U/ 33 12/ 27 26/ 7	12/ 42 9/ 27 U/ 24 3/ 3 26/ 3	U/ 29 9/ 24 12/ 14 17/ 10 26/ 10	3/ 43 12/ 21 9/ 14 13/ 7 15/ 7	9/ 50 2/ 17 8/ 17 U/ 17	12/ 29 U/ 29 5/ 14 9/ 14 15/ 14
MOST FREQUENT DURATION (NUMBER OF 12HR PERIODS/ FREQUENCY	1/100	1/100	1/100	1/ 60 2/ 20 3/ 10 4/ 10	1/ 63 2/ 31 3/ 6	1/ 58 2/ 33 3/ 8	1/ 73 2/ 18 3/ 9	1/ 56 2/ 33 3/ 11	1/ 88 2/ 13	1/ 90 4/ 10	1/100	1/ 60 2/ 40

****
* MAP TYPE 13 *
****

ALBERTA WINDOW
****
PERIOD OF RECORD
1946-1971
****
THIS TYPE
OCCURRED 249 TIMES
DURING THE PERIOD
OF RECORD

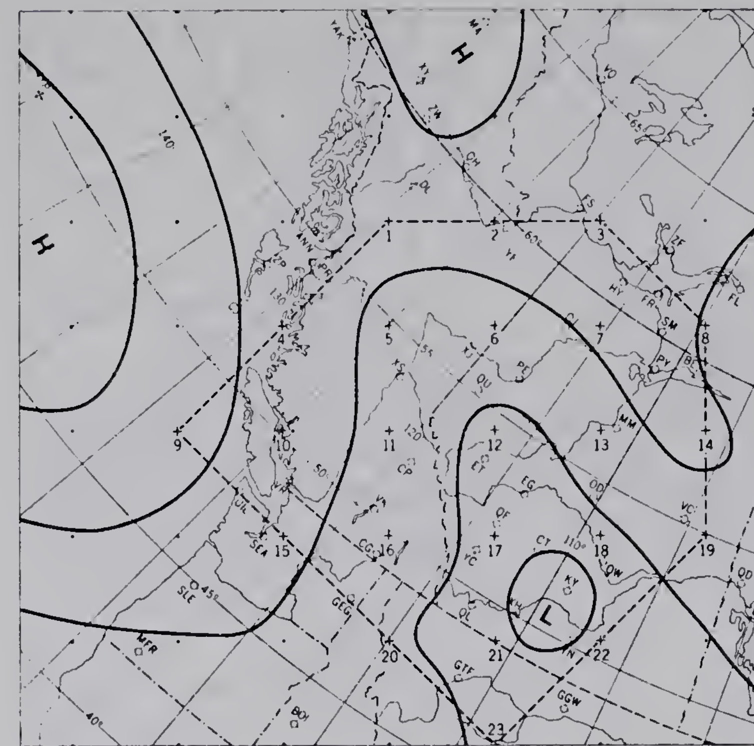


CHARACTERISTICS

MONTH	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
NUMBER OF OCCURRENCES	0	1	2	5	18	34	68	70	30	13	4	4
FREQUENCIES OF OCCURRENCES	0	0	0	0	1	3	5	6	3	1	0	0
MAP TYPE MOST FREQUENTLY FOLLOWING (MAP TYPE/ FREQUENCY)		7/100	9/100	U/100	U/ 43 13/ 36 4/ 7 14/ 7 28/ 7	U/ 44 13/ 38 4/ 13 7/ 6	13/ 45 U/ 36 4/ 11 6/ 4 7/ 2	U/ 36 13/ 32 4/ 20 7/ 6 2/ 4	U/ 42 7/ 21 4/ 11 13/ 11 17/ 11	7/ 33 28/ 22 2/ 11 4/ 11 13/ 11	3/ 33 7/ 33 U/ 33	13/ 50 U/ 50
MOST FREQUENT DURATION (NUMBER OF 12HR PERIODS/ FREQUENCY		1/100		1/100	1/ 56 2/ 33 3/ 11	1/ 67 2/ 22 3/ 11	1/ 44 2/ 36 3/ 12 4/ 8	1/ 71 2/ 15 3/ 12 4/ 3	1/ 94 3/ 6	1/ 86 2/ 14	1/100	1/ 50 3/ 50

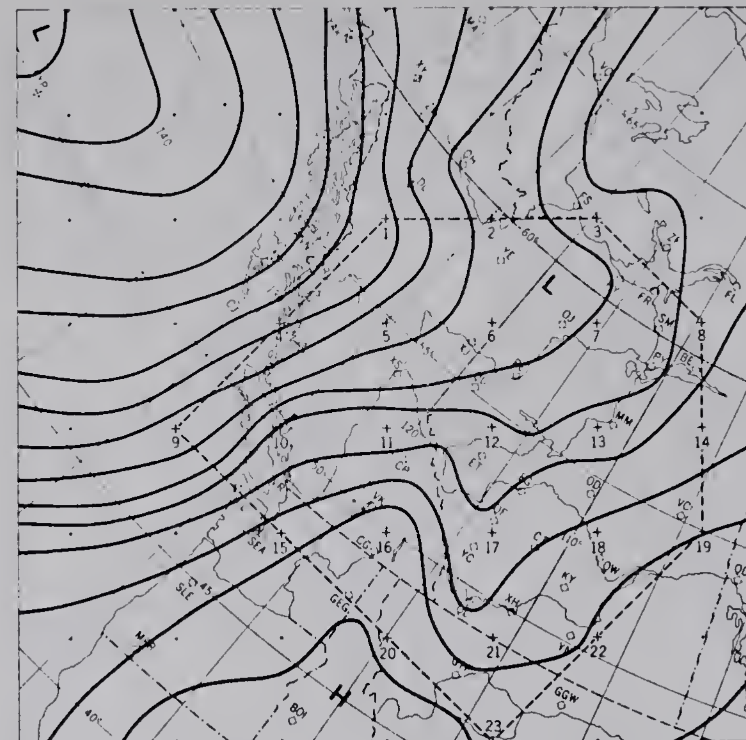
****
* MAP TYPE 14 *
****

ALBERTA WINDOW
****
PERIOD OF RECORD
1946-1971
****
THIS TYPE
OCCURRED 217 TIMES
DURING THE PERIOD
OF RECORD



CHARACTERISTICS

MONTH	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
NUMBER OF OCCURRENCES	6	10	18	24	51	32	25	19	17	6	3	6
FREQUENCIES OF OCCURRENCES	0	1	1	2	4	3	2	2	1	0	0	0
MAP TYPE MOST FREQUENTLY FOLLOWING (MAP TYPE/ FREQUENCY)	U/ 50 4/ 25 19/ 25	6/ 43 14/ 14 19/ 14 25/ 14 U/ 14	U/ 38 19/ 15 25/ 15 4/ 8 6/ 8	14/ 33 20/ 17 U/ 17 19/ 11 4/ 6	4/ 30 14/ 24 6/ 15 20/ 12 19/ 9	14/ 43 U/ 22 4/ 13 20/ 13 19/ 9	14/ 32 4/ 21 U/ 21 6/ 11 19/ 11	U/ 43 4/ 14 L/ 14 20/ 14 19/ 7	U/ 43 14/ 21 4/ 14 20/ 14 6/ 7	U/ 40 14/ 20 20/ 20 25/ 20	U/100	20/100
MOST FREQUENT DURATION (NUMBER OF 12HR PERIODS/ FREQUENCY	1/100	1/ 83 2/ 17	1/ 91 2/ 9	1/ 64 2/ 36	1/ 74 2/ 26	2/ 54 1/ 46	1/ 85 3/ 8 4/ 8	1/100	1/ 73 2/ 27	1/ 75 2/ 25	1/100	1/100



****
* MAP TYPE 15 *
****

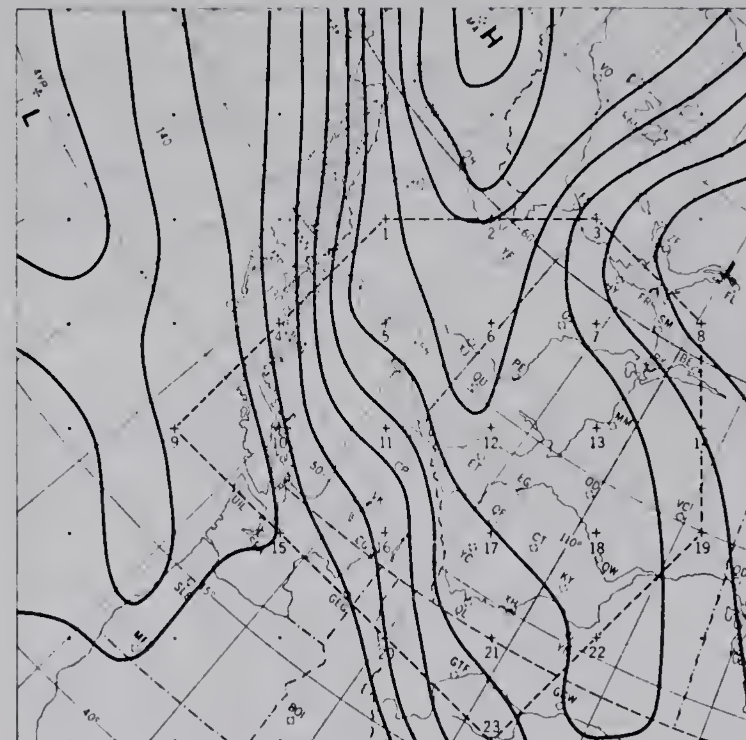
ALBERTA WINDOW
****
PERIOD OF RECORD
1946-1971
****
THIS TYPE
OCCURRED 483 TIMES
DURING THE PERIOD
OF RECORD

CHARACTERISTICS

MONTH	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
NUMBER OF OCCURRENCES	48	41	26	33	8	5	2	4	16	97	91	112
FREQUENCIES OF OCCURRENCES	4	4	2	3	1	0	0	0	1	8	7	9
MAP TYPE MOST FREQUENTLY FOLLOWING (MAP TYPE/ FREQUENCY)	15/ 37 U/ 20 3/ 17 2/ 3 5/ 3	15/ 22 3/ 19 21/ 19 8/ 7 11/ 7	U/ 18 3/ 12 11/ 12 12/ 12 15/ 12	15/ 20 21/ 20 12/ 15 3/ 10 U/ 10	12/ 67 33/ 33	U/ 40 2/ 20 15/ 20 33/ 20		12/100	3/ 40 21/ 40 U/ 20	15/ 38 3/ 23 21/ 9 33/ 8 U/ 8	15/ 33 3/ 23 U/ 13 8/ 5 9/ 5	15/ 42 3/ 12 U/ 12 11/ 7 21/ 4
MOST FREQUENT DURATION (NUMBER OF 12HR PERIODS/ FREQUENCY	1/ 47 2/ 47 3/ 6	1/ 79 2/ 21	1/ 86 2/ 14	1/ 75 2/ 25	1/100	1/ 75 2/ 25		1/100	1/100	1/ 66 2/ 22 3/ 7 4/ 5	1/ 68 2/ 30 4/ 3	1/ 66 2/ 20 3/ 12 5/ 2

****
* MAP TYPE 16 *
****

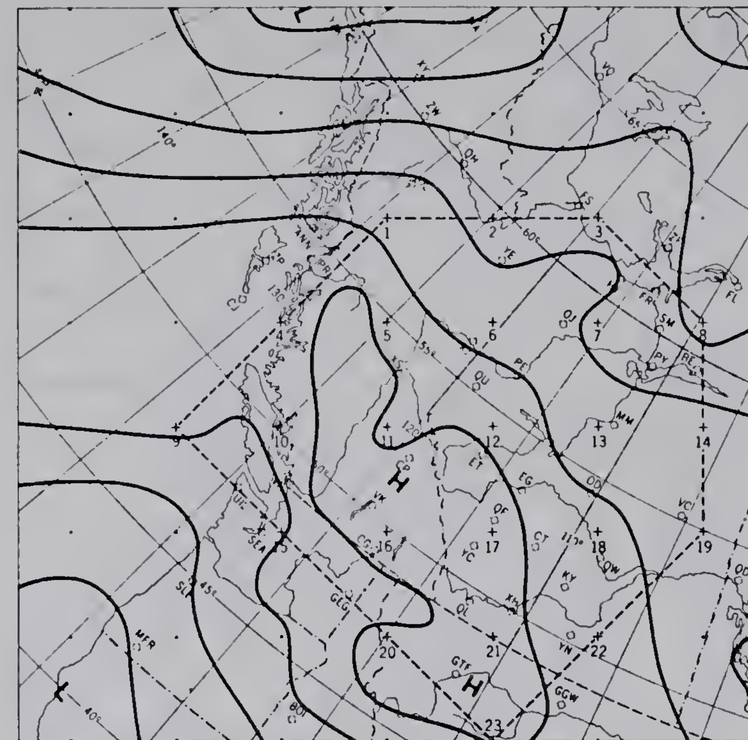
ALBERTA WINDOW
****
PERIOD OF RECORD
1946-1971
****
THIS TYPE
OCCURRED 224 TIMES
DURING THE PERIOD
OF RECORD



CHARACTERISTICS

MONTH	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
NUMBER OF OCCURRENCES	85	22	12	6	5	4	1	2	11	6	25	45
FREQUENCIES OF OCCURRENCES	7	2	1	1	0	0	0	0	1	0	2	4
MAP TYPE MOST FREQUENTLY FOLLOWING (MAP TYPE/ FREQUENCY)	16/ 64 U/ 16 1/ 9 27/ 5 5/ 2	16/ 27 27/ 27 U/ 27 1/ 9 18/ 9	16/ 50 U/ 38 27/ 13	16/ 40 1/ 20 6/ 20 U/ 20	U/ 40 1/ 20 16/ 20 27/ 20	16/ 50 U/ 50			1/ 38 27/ 25 10/ 13 32/ 13 U/ 13	16/ 50 8/ 25 27/ 25	16/ 38 27/ 24 30/ 14 U/ 10 1/ 5	16/ 50 27/ 21 U/ 21 1/ 6 8/ 3
MOST FREQUENT DURATION (NUMBER OF 12HR PERIODS/ FREQUENCY	1/ 45 2/ 20 3/ 10 4/ 10	1/ 63 2/ 38	2/ 50 1/ 25 3/ 25	1/ 67 3/ 33	1/ 67 2/ 33	2/100			1/100	2/100	1/ 62 2/ 23 3/ 15	1/ 44 2/ 25 3/ 19 4/ 6

MAP TYPE 16



****
* MAP TYPE 17 *
****

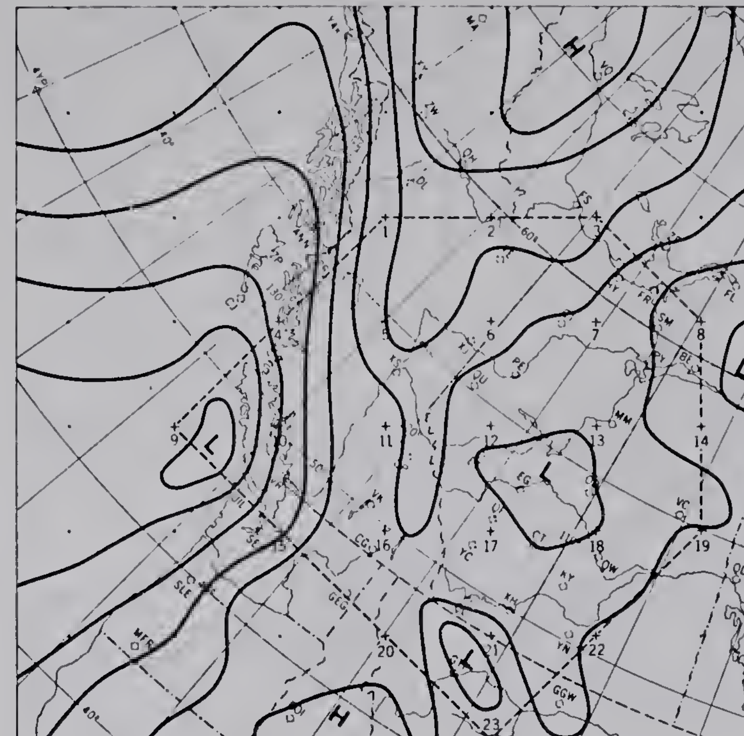
ALBERTA WINDOW
****
PERIOD OF RECORD
1946-1971
****
THIS TYPE
OCCURRED 289 TIMES
DURING THE PERIOD
OF RECORD

CHARACTERISTICS

MONTH	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
NUMBER OF OCCURRENCES	16	15	10	8	13	15	50	29	54	46	19	14
FREQUENCIES OF OCCURRENCES	1	1	1	1	1	1	4	2	5	4	2	1
MAP TYPE MOST FREQUENTLY FOLLOWING (MAP TYPE/ FREQUENCY)	4/ 25 17/ 25 7/ 13 29/ 13 31/ 13	7/ 36 2/ 27 U/ 27 17/ 9	2/ 29 U/ 29 3/ 14 17/ 14 27/ 14	2/ 33 7/ 33 15/ 33	3/ 50 17/ 25 U/ 25	U/ 67 2/ 17 9/ 17	U/ 65 17/ 22 2/ 9 13/ 4	17/ 43 2/ 14 9/ 14 U/ 14 4/ 5	17/ 28 U/ 28 2/ 19 3/ 9 7/ 6	17/ 29 2/ 25 3/ 18 U/ 18 7/ 7	2/ 33 17/ 17 U/ 17 3/ 8 7/ 8	17/ 45 2/ 27 3/ 9 4/ 9 U/ 9
MOST FREQUENT DURATION (NUMBER OF 12HR PERIODS/ FREQUENCY	1/ 83 2/ 17	1/ 89 2/ 11	1/ 83 2/ 17	1/100	1/ 67 2/ 33	1/100	1/ 72 2/ 28	1/ 45 2/ 27 3/ 27	1/ 78 2/ 13 3/ 4 5/ 4	1/ 67 2/ 22 3/ 11	1/ 90 3/ 10	1/ 67 2/ 33

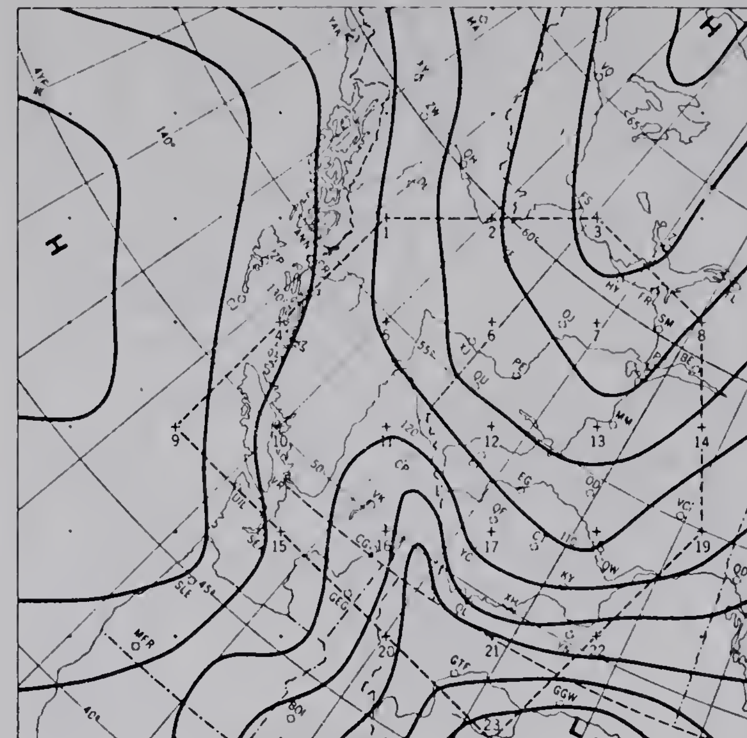
****
* MAP TYPE 18 *
****

ALBERTA WINDOW
****
PERIOD OF RECORD
1946-1971
****
THIS TYPE
OCCURRED 47 TIMES
DURING THE PERIOD
OF RECORD



CHARACTERISTICS

MONTH	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
NUMBER OF OCCURRENCES	16	6	1	1	0	0	1	1	1	2	9	9
FREQUENCIES OF OCCURRENCES	1	1	0	0	0	0	0	0	0	0	1	1
MAP TYPE MOST FREQUENTLY FOLLOWING (MAP TYPE/ FREQUENCY)	18/ 31 16/ 23 27/ 15 U/ 15 11/ 8	U/ 33 16/ 17 18/ 17 27/ 17 32/ 17	U/100	U/100				27/100		30/100	16/ 60 1/ 20 27/ 20	8/ 75 27/ 25
MOST FREQUENT DURATION (NUMBER OF 12HR PERIODS/ FREQUENCY	1/ 67 2/ 22 3/ 11	1/ 75 2/ 25	1/100	1/100				1/100		1/100	1/100	1/100

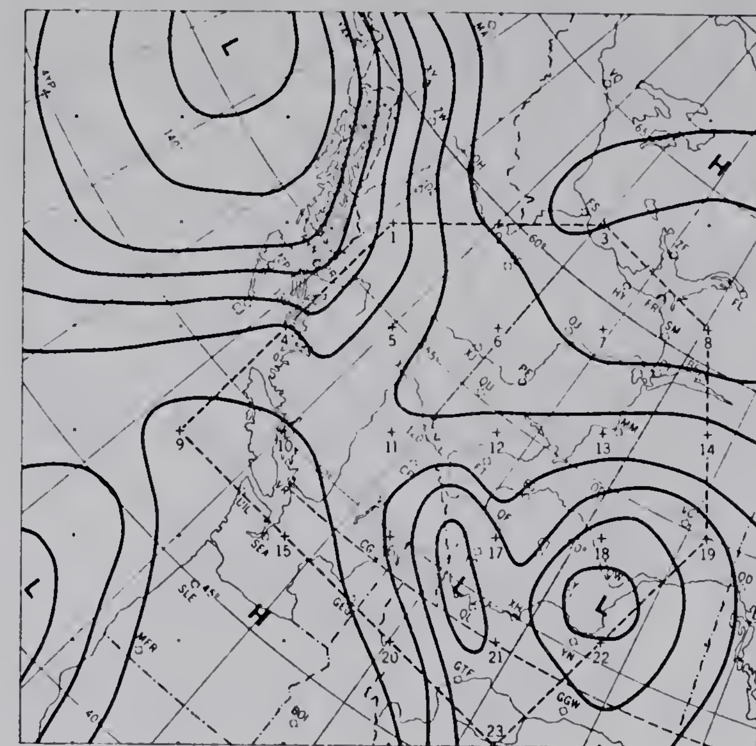


* * * * * * * * * * * * * * * *
* MAP TYPE 19 *
* * * * * * * * * * * * * * * *

ALBERTA WINDOW
****
PERIOD OF RECORD
1946-1971
****
THIS TYPE
OCCURRED 245 TIMES
DURING THE PERIOD
OF RECORD

CHARACTERISTICS

MONTH	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
NUMBER OF OCCURRENCES	20	18	31	29	36	34	16	20	12	8	10	11
FREQUENCIES OF OCCURRENCES	2	2	3	2	3	3	1	2	1	1	1	1
MAP TYPE MOST FREQUENTLY FOLLOWING (MAP TYPE/ FREQUENCY)	1/ 31 19/ 23 U/ 23 10/ 15 27/ 8	U/ 56 1/ 22 6/ 11 19/ 11	19/ 35 1/ 24 U/ 24 20/ 6 27/ 6	U/ 42 19/ 29 1/ 17 6/ 4 12/ 4	19/ 48 U/ 28 1/ 8 6/ 4 14/ 4	19/ 42 U/ 31 1/ 8 6/ 4 10/ 4	1/ 30 19/ 30 6/ 10 10/ 10 14/ 10	U/ 41 19/ 29 1/ 18 10/ 6 30/ 6	U/ 40 19/ 30 6/ 10 12/ 10 20/ 10	1/ 50 U/ 50	30/ 43 10/ 29 33/ 14 U/ 14	U/ 33 1/ 17 5/ 17 18/ 17 27/ 17
MOST FREQUENT DURATION (NUMBER OF 12HR PERIODS/ FREQUENCY	1/ 78 2/ 11 3/ 11	1/100	1/ 64 2/ 27 3/ 9	1/ 69 2/ 25 3/ 6	2/ 58 1/ 25 3/ 17	1/ 62 2/ 23 5/ 15	1/ 57 2/ 43	1/ 75 3/ 17 2/ 8	1/ 67 2/ 17 3/ 17	1/100	1/100	1/100



****
* MAP TYPE 20 *
****

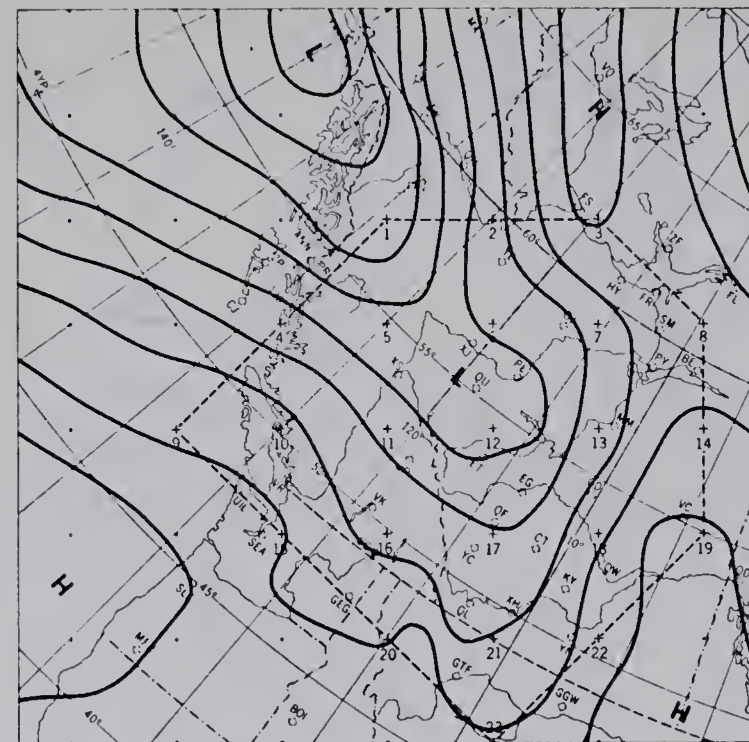
ALBERTA WINDOW
****
PERIOD OF RECORD
1946-1971
****
THIS TYPE
OCCURRED 141 TIMES
DURING THE PERIOD
OF RECORD

CHARACTERISTICS

MONTH	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
NUMBER OF OCCURRENCES	19	10	25	19	14	15	2	6	6	5	10	10
FREQUENCIES OF OCCURRENCES	2	1	2	2	1	1	0	0	1	0	1	1
MAP TYPE MOST FREQUENTLY FOLLOWING (MAP TYPE/ FREQUENCY)	U/ 50 1/ 20 32/ 20 6/ 10	U/ 67 32/ 33	U/ 50 11/ 13 1/ 6 6/ 6 8/ 6	20/ 36 19/ 21 U/ 21 4/ 7 6/ 7	U/ 29 10/ 14 20/ 14 23/ 14 25/ 14	U/ 70 19/ 30		19/ 33 14/ 17 20/ 17 25/ 17 32/ 17	6/ 17 14/ 17 19/ 17 20/ 17 23/ 17	19/ 50 20/ 50	6/ 40 U/ 40 20/ 20	1/ 33 6/ 17 11/ 17 20/ 17 U/ 17
MOST FREQUENT DURATION (NUMBER OF 12HR PERIODS/ FREQUENCY	1/100	1/100	1/ 93 2/ 7	1/ 67 3/ 22 2/ 11	1/ 80 2/ 20	1/100		1/ 80 2/ 20	1/ 80 2/ 20	1/100	1/100	1/ 80 2/ 20

****
* MAP TYPE 21 *
****

ALBERTA WINDOW
****
PERIOD OF RECORD
1946-1971
****
THIS TYPE
OCCURRED 140 TIMES
DURING THE PERIOD
OF RECORD

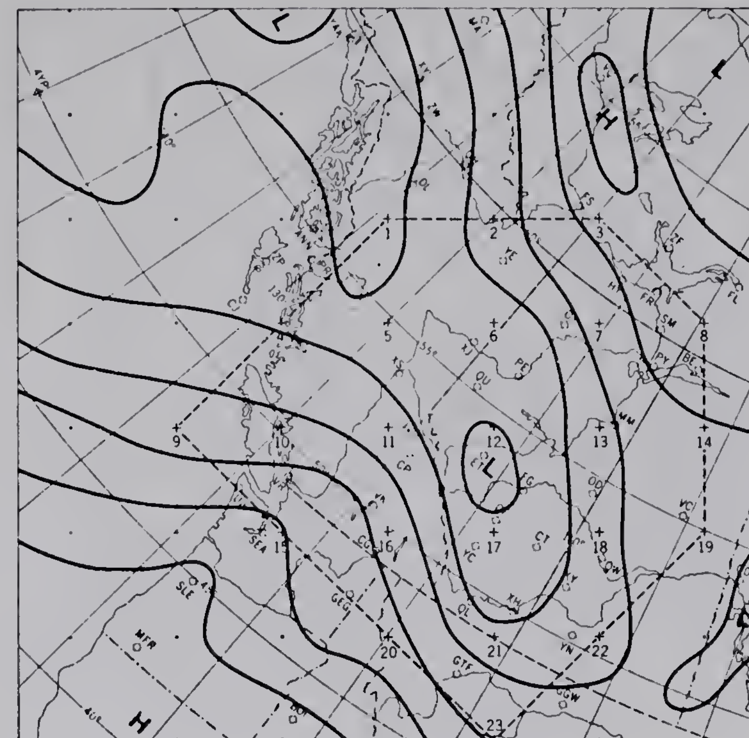


CHARACTERISTICS

MONTH	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
NUMBER OF OCCURRENCES	12	30	25	15	9	2	0.	2	4	14	11	16
FREQUENCIES OF OCCURRENCES	1	3	2	1	1	0	0	0	0	1	1	1
MAP TYPE MOST FREQUENTLY FOLLOWING (MAP TYPE/ FREQUENCY)	U/ 50 9/ 17 21/ 17 32/ 17	U/ 23 31/ 14 4/ 9 11/ 9 21/ 9	U/ 50 9/ 11 21/ 11 33/ 11 3/ 6	33/ 25 2/ 13 4/ 13 9/ 13 22/ 13	U/ 57 14/ 14 21/ 14 25/ 14				9/ 50 3/ 25 4/ 25	U/ 40 2/ 20 9/ 20 3/ 10 33/ 10	U/ 38 31/ 25 33/ 25 15/ 13	31/ 50 15/ 25 2/ 13 U/ 13
MOST FREQUENT DURATION (NUMBER OF 12HR PERIODS/ FREQUENCY	1/ 80 2/ 20	1/ 89 2/ 11	1/ 87 2/ 13	1/100	1/ 83 2/ 17				1/100	1/100	1/100	1/100

****
* MAP TYPE 22 *
****

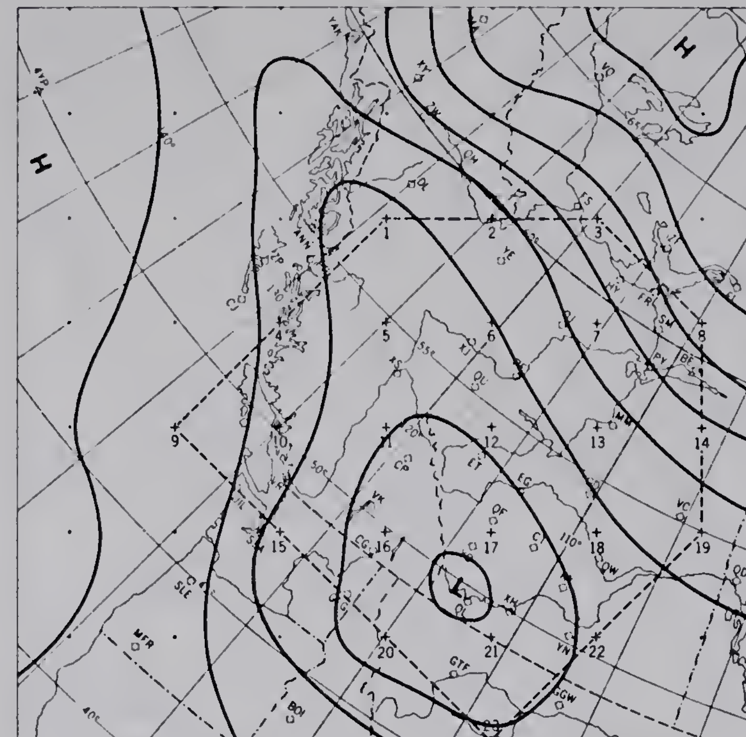
ALBERTA WINDOW
****
PERIOD OF RECORD
1946-1971
****
THIS TYPE
OCCURRED 72 TIMES
DURING THE PERIOD
OF RECORD



CHARACTERISTICS

MONTH	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
NUMBER OF OCCURRENCES	11	19	7	5	1	1	0	1	3	4	9	11
FREQUENCIES OF OCCURRENCES	1	2	1	0	0	0	0	0	0	0	1	1
MAP TYPE MOST FREQUENTLY FOLLOWING (MAP TYPE/ FREQUENCY)	U/ 67 11/ 17 15/ 17	22/ 44 4/ 11 14/ 11 33/ 11 21/ 6	U/ 80 23/ 20	11/ 50 U/ 50				4/100	31/100	2/ 50 U/ 50	11/ 43 2/ 14 15/ 14 31/ 14 33/ 14	33/ 29 U/ 29 11/ 14 15/ 14 20/ 14
MOST FREQUENT DURATION (NUMBER OF 12HR PERIODS/ FREQUENCY	1/100	1/ 60 2/ 20 3/ 10 5/ 10	1/100	1/100				1/100	1/100	1/100	1/100	1/100

MAP TYPE 22



****
* MAP TYPE 23 *
****

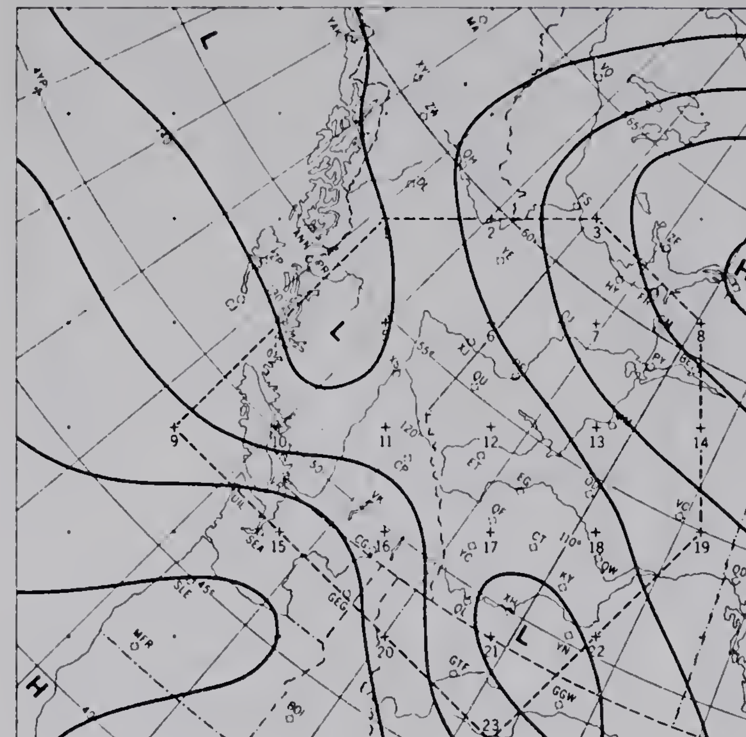
ALBERTA WINDOW
****
PERIOD OF RECORD
1946-1971
****
THIS TYPE
OCCURRED 145 TIMES
DURING THE PERIOD
OF RECORD

CHARACTERISTICS

MONTH	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
NUMBER OF OCCURRENCES	7	11	15	29	27	17	9	6	6	6	4	8
FREQUENCIES OF OCCURRENCES	1	1	1	2	2	1	1	0	1	0	0	1
MAP TYPE MOST FREQUENTLY FOLLOWING (MAP TYPE/ FREQUENCY)	10/ 29 1/ 14 14/ 14 19/ 14 23/ 14	10/ 33 19/ 17 21/ 17 23/ 17 U/ 17	19/ 40 1/ 30 14/ 10 20/ 10 32/ 10	23/ 30 19/ 20 24/ 15 20/ 10 U/ 10	23/ 33 14/ 17 10/ 11 19/ 11 U/ 11	14/ 21 23/ 21 U/ 21 1/ 7 6/ 7	23/ 50 19/ 17 25/ 17 U/ 17	U/ 50 10/ 25 19/ 25	14/ 33 1/ 17 23/ 17 24/ 17 U/ 17	19/ 33 U/ 33 1/ 17 20/ 17	19/100	20/ 50 U/ 50
MOST FREQUENT DURATION (NUMBER OF 12HR PERIODS/ FREQUENCY	1/ 80 2/ 20	1/ 80 2/ 20	1/100	1/ 58 2/ 33 3/ 8	1/ 67 2/ 17 3/ 17	1/ 82 2/ 9 3/ 9	2/100	1/100	1/ 80 2/ 20	1/100	1/100	1/100

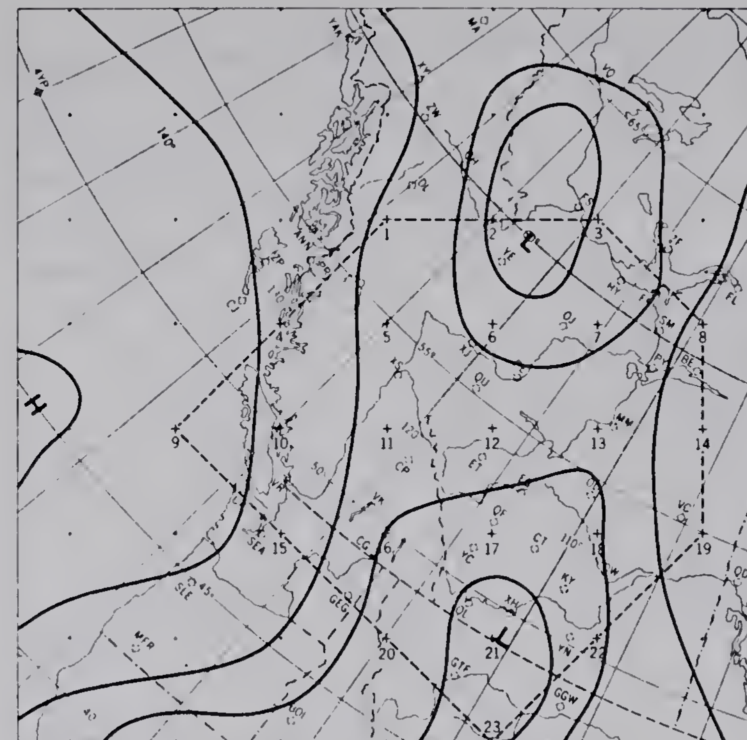
****
* MAP TYPE 24 *
****

ALBERTA WINDOW
****
PERIOD OF RECORD
1946-1971
****
THIS TYPE
OCCURRED 79 TIMES
DURING THE PERIOD
OF RECORD



CHARACTERISTICS

MONTH	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
NUMBER OF OCCURRENCES	7	10	13	15	4	2	0	2	4	3	6	13
FREQUENCIES OF OCCURRENCES	1	1	1	1	0	0	0	0	0	0	0	1
MAP TYPE MOST FREQUENTLY FOLLOWING (MAP TYPE/ FREQUENCY)	20/ 33 U/ 33 10/ 17 19/ 17	U/ 33 21/ 17 22/ 17 23/ 17 24/ 17	11/ 33 24/ 22 10/ 11 23/ 11 32/ 11	U/ 58 11/ 8 15/ 8 23/ 8 24/ 8	11/ 50 14/ 50	U/100		U/100	24/ 50 U/ 50	11/ 50 32/ 50	U/ 40 27/ 20 31/ 20 32/ 20	11/ 33 U/ 22 5/ 11 23/ 11 24/ 11
MOST FREQUENT DURATION (NUMBER OF 12HR PERIODS/ FREQUENCY	1/100	1/ 80 2/ 20	1/ 71 2/ 29	1/ 90 2/ 10	1/100	1/100		1/100	1/100	1/100	1/100	1/ 88 2/ 13

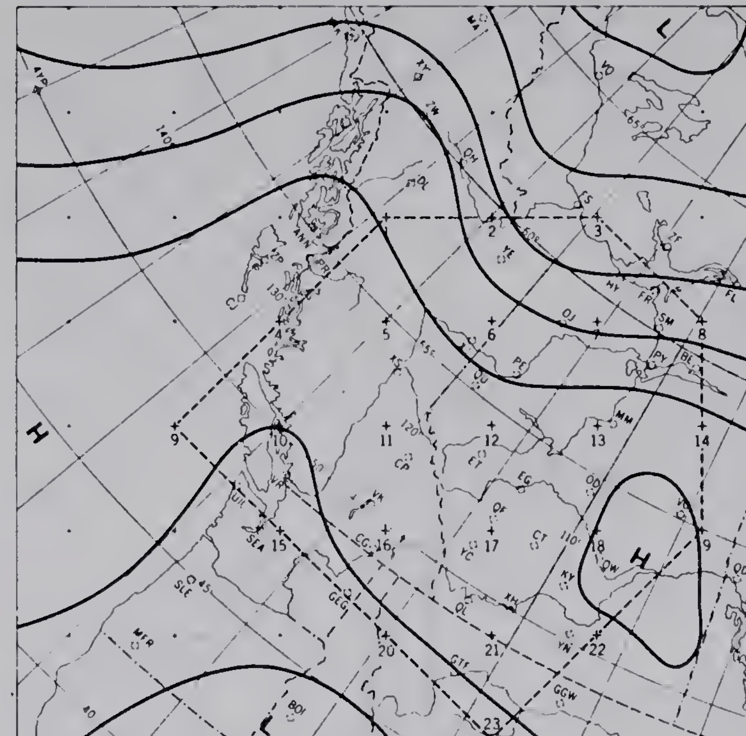


****
* MAP TYPE 25 *
****

ALBERTA WINDOW
****
PERIOD OF RECORD
1946-1971
****
THIS TYPE
OCCURRED 156 TIMES
DURING THE PERIOD
OF RECORD

CHARACTERISTICS

MONTH	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
NUMBER OF OCCURRENCES	1	3	3	15	38	31	26	19	10	2	4	4
FREQUENCIES OF OCCURRENCES	0	0	0	1	3	3	2	2	1	0	0	0
MAP TYPE MOST FREQUENTLY FOLLOWING (MAP TYPE/ FREQUENCY)		U/100	14/ 50 U/ 50	9/ 36 U/ 36 25/ 18 4/ 9	25/ 40 9/ 20 U/ 20 4/ 16 3/ 4	25/ 30 U/ 30 4/ 15 14/ 10 2/ 5	U/ 37 25/ 32 4/ 21 9/ 11	4/ 29 U/ 29 9/ 14 2/ 7 14/ 7	U/ 63 25/ 25 4/ 13	9/ 50 U/ 50	U/ 67 25/ 33	9/ 50 4/ 25 13/ 25
MOST FREQUENT DURATION (NUMBER OF 12HR PERIODS/ FREQUENCY		1/100	1/100	1/ 78 2/ 22	1/ 67 2/ 20 3/ 7 5/ 7	1/ 75 3/ 17 2/ 8	1/100	1/ 92 2/ 8	1/ 67 2/ 33	1/100	1/ 50 2/ 50	1/100

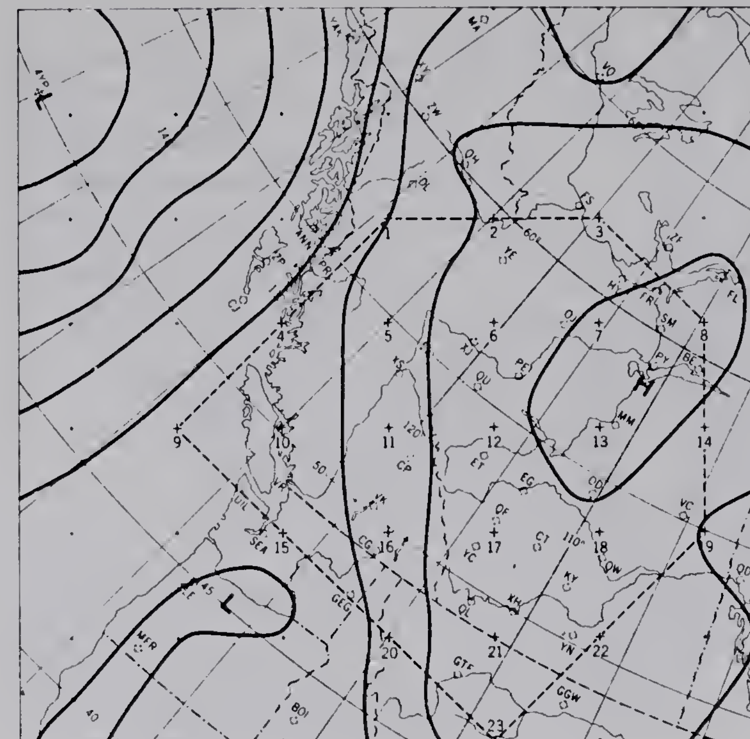


****
* MAP TYPE 26 *
****

ALBERTA WINDOW
****
PERIOD OF RECORD
1946-1971
****
THIS TYPE
OCCURRED 114 TIMES
DURING THE PERIOD
OF RECORD

CHARACTERISTICS

MONTH	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
NUMBER OF OCCURRENCES	1	5	5	4	14	9	13	36	16	5	5	1
FREQUENCIES OF OCCURRENCES	0	0	0	0	1	1	1	3	1	0	0	0
MAP TYPE MOST FREQUENTLY FOLLOWING (MAP TYPE/ FREQUENCY)	U/100	3/100	2/ 33 12/ 33 17/ 33	17/ 67 U/ 33	U/ 67 2/ 11 3/ 11 17/ 11	U/ 60 17/ 20 26/ 20	9/ 33 U/ 33 17/ 17 26/ 17	26/ 36 U/ 28 17/ 12 9/ 8 3/ 4	26/ 25 U/ 25 3/ 17 17/ 17 2/ 8	9/ 33 17/ 33 U/ 33	2/ 20 12/ 20 15/ 20 17/ 20 26/ 20	17/100
MOST FREQUENT DURATION (NUMBER OF 12HR PERIODS/ FREQUENCY	1/100	1/100	1/100	1/100	1/100	1/ 75 2/ 25	1/ 75 2/ 25	1/ 81 2/ 6 3/ 6 7/ 6	1/ 78 2/ 11 3/ 11	1/100	1/ 75 2/ 25	1/100



****
* MAP TYPE 27 *
****

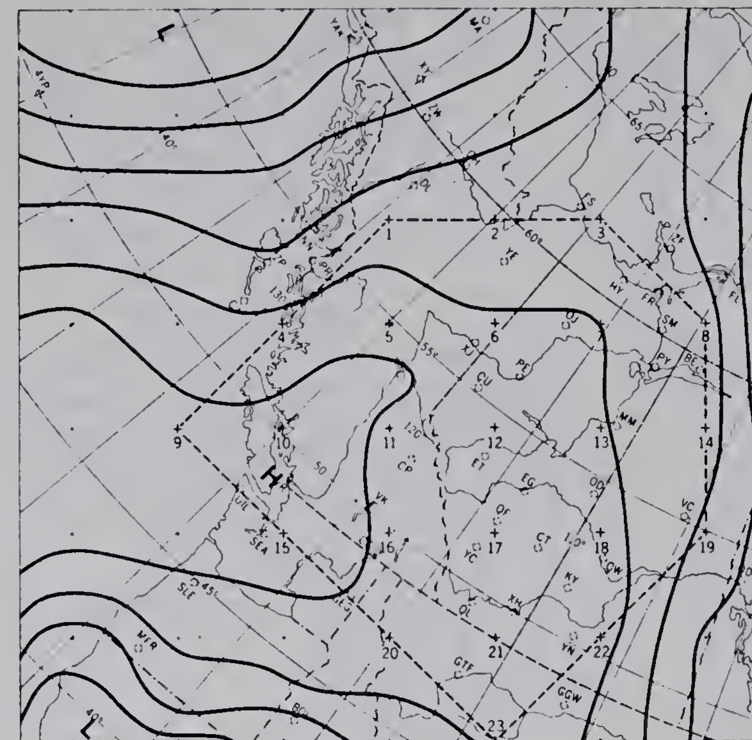
ALBERTA WINDOW
****
PERIOD OF RECORD
1946-1971
****
THIS TYPE
OCCURRED 590 TIMES
DURING THE PERIOD
OF RECORD

CHARACTERISTICS

MONTH	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
NUMBER OF OCCURRENCES	109	80	114	42	38	18	7	22	22	25	40	73
FREQUENCIES OF OCCURRENCES	9	7	9	4	3	2	1	2	2	2	3	6
MAP TYPE MOST FREQUENTLY FOLLOWING (MAP TYPE/ FREQUENCY)	27/ 48 1/ 19 U/ 7 5/ 6 10/ 6	27/ 54 1/ 12 U/ 11 5/ 9 10/ 5	27/ 52 5/ 18 1/ 10 10/ 10 U/ 5	27/ 45 10/ 18 1/ 9 5/ 9 11/ 5	27/ 48 5/ 33 11/ 10 U/ 10	27/ 42 U/ 17 1/ 8 5/ 8 8/ 8	5/ 33 U/ 33 10/ 17 27/ 17	27/ 43 5/ 21 1/ 14 U/ 14 10/ 7	10/ 21 27/ 21 U/ 21 5/ 14 1/ 7	27/ 33 U/ 22 5/ 17 11/ 11 8/ 6	27/ 34 U/ 14 1/ 10 5/ 7 8/ 7	27/ 53 1/ 18 5/ 9 11/ 5 U/ 5
MOST FREQUENT DURATION (NUMBER OF 12HR PERIODS/ FREQUENCY	1/ 51 2/ 23 3/ 12 4/ 9	1/ 40 2/ 36 3/ 12 7/ 8	1/ 45 2/ 26 3/ 13 5/ 11	1/ 50 2/ 25 3/ 17 4/ 8	1/ 45 2/ 36 3/ 18	1/ 83 4/ 17	1/ 75 2/ 25	2/ 57 1/ 43	1/ 80 2/ 20	1/ 58 2/ 33 3/ 8	1/ 78 3/ 11 2/ 6 5/ 6	1/ 59 2/ 23 4/ 14 5/ 5

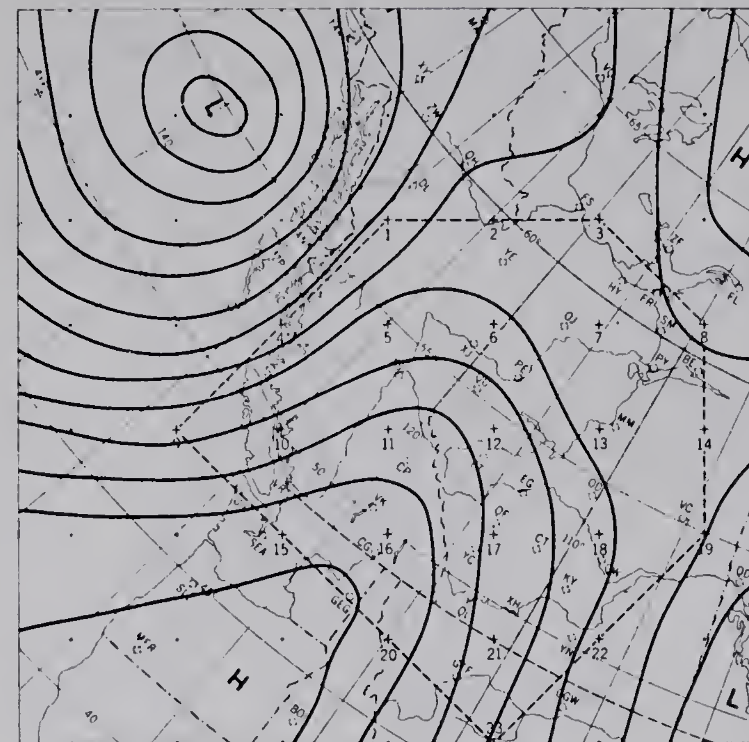
****
* MAP TYPE 28 *
****

ALBERTA WINDOW
****
PERIOD OF RECORD
1946-1971
****
THIS TYPE
OCCURRED 112 TIMES
DURING THE PERIOD
OF RECORD



CHARACTERISTICS

MONTH	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
NUMBER OF OCCURRENCES	4	3	5	3	9	9	11	14	25	18	7	4
FREQUENCIES OF OCCURRENCES	0	0	0	0	1	1	1	1	2	1	1	0
MAP TYPE MOST FREQUENTLY FOLLOWING (MAP TYPE/ FREQUENCY)	2/100	3/ 33 9/ 33 29/ 33	9/ 67 U/ 33	15/100	2/ 33 28/ 33 17/ 17 U/ 17	4/ 40 2/ 20 9/ 20 U/ 20	U/ 67 3/ 17 17/ 17	3/ 30 U/ 30 28/ 20 2/ 10 29/ 10	3/ 37 U/ 16 2/ 11 9/ 11 17/ 11	3/ 33 7/ 11 9/ 11 17/ 11 31/ 11	3/ 50 9/ 50	3/ 67 2/ 33
MOST FREQUENT DURATION (NUMBER OF 12HR PERIODS/ FREQUENCY	1/100	1/100	1/100	1/100	1/ 67 3/ 33	1/100	1/100	1/ 75 2/ 25	1/ 94 2/ 6	1/100	1/100	1/100

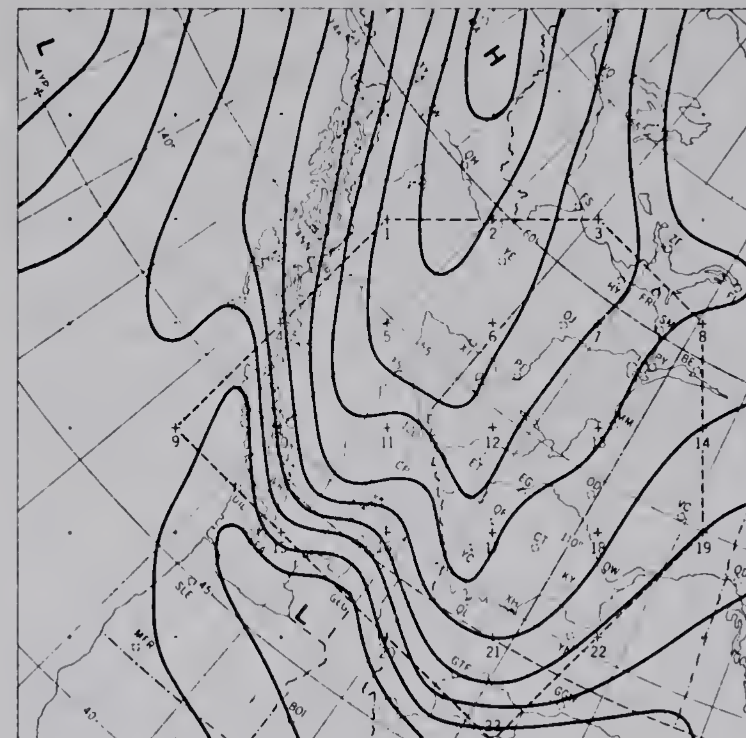


****
* MAP TYPE 29 *
****

ALBERTA WINDOW
****
PERIOD OF RECORD
1946-1971
****
THIS TYPE
OCCURRED 137 TIMES
DURING THE PERIOD
OF RECORD

CHARACTERISTICS

MONTH	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
NUMBER OF OCCURRENCES	15	11	8	10	1	6	1	2	7	29	22	25
FREQUENCIES OF OCCURRENCES	1	1	1	1	0	1	0	0	1	2	2	2
MAP TYPE MOST FREQUENTLY FOLLOWING (MAP TYPE/ FREQUENCY)	3/ 50 15/ 50	U/ 40 3/ 20 15/ 20 33/ 20	3/ 50 15/ 25 31/ 25	15/ 60 33/ 20 U/ 20	15/100	3/ 50 28/ 25 U/ 25	8/100	U/100	3/ 50 2/ 17 9/ 17 33/ 17	15/ 36 3/ 23 29/ 18 2/ 5 8/ 5	15/ 50 3/ 30 33/ 10 U/ 10	15/ 41 3/ 24 33/ 12 2/ 6 8/ 6
MOST FREQUENT DURATION (NUMBER OF 12HR PERIODS/ FREQUENCY	1/100	1/100	1/100	1/100	1/100	1/100	1/100	1/100	1/100	1/ 94 5/ 6	1/100	1/ 92 2/ 8



****
* MAP TYPE 30 *
****

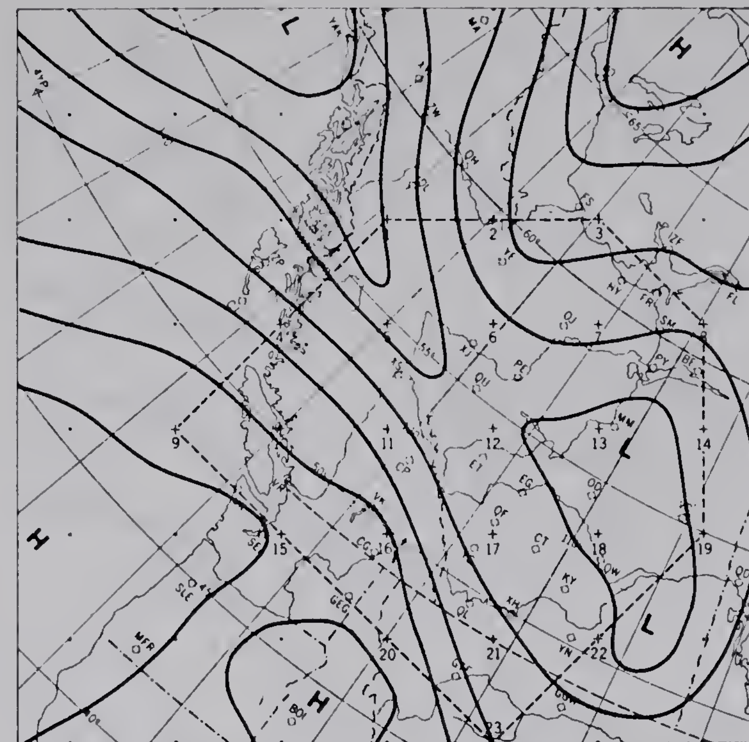
ALBERTA WINDOW
****
PERIOD OF RECORD
1946-1971
****
THIS TYPE
OCCURRED 161 TIMES
DURING THE PERIOD
OF RECORD

CHARACTERISTICS

MONTH	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
NUMBER OF OCCURRENCES	23	10	9	6	5	3	4	14	20	15	26	26
FREQUENCIES OF OCCURRENCES	2	1	1	1	0	0	0	1	2	1	2	2
MAP TYPE MOST FREQUENTLY FOLLOWING (MAP TYPE/ FREQUENCY)	16/ 28 U/ 28 30/ 17 17/ 11 27/ 11	30/ 40 U/ 40 16/ 20	16/ 33 27/ 33 30/ 17 U/ 17	U/ 75 16/ 25	6/ 25 16/ 25 27/ 25 30/ 25	U/100		30/ 30 U/ 30 1/ 20 27/ 20	U/ 56 30/ 25 1/ 13 16/ 6	U/ 44 1/ 22 16/ 11 18/ 11 30/ 11	U/ 43 30/ 24 16/ 14 1/ 10 18/ 10	30/ 41 U/ 32 16/ 18 1/ 5 8/ 5
MOST FREQUENT DURATION (NUMBER OF 12HR PERIODS/ FREQUENCY	1/ 83 2/ 17	1/ 67 3/ 33	1/ 75 2/ 25	1/100	1/ 67 2/ 33	1/100		1/ 57 2/ 43	1/ 75 2/ 17 3/ 8	1/ 83 2/ 17	1/ 81 3/ 13 2/ 6	1/ 54 2/ 31 3/ 8 4/ 8

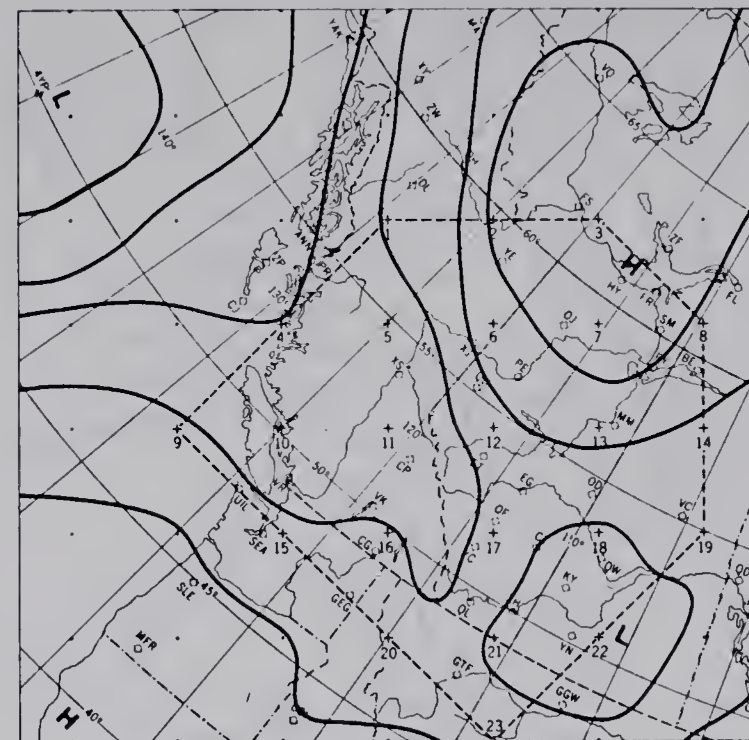
****
* MAP TYPE 31 *
****

ALBERTA WINDOW
****
PERIOD OF RECORD
1946-1971
****
THIS TYPE
OCCURRED 137 TIMES
DURING THE PERIOD
OF RECORD



CHARACTERISTICS

MONTH	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
NUMBER OF OCCURRENCES	18	23	13	12	1	5	2	4	6	12	23	18
FREQUENCIES OF OCCURRENCES	1	2	1	1	0	0	0	0	1	1	2	1
MAP TYPE MOST FREQUENTLY FOLLOWING (MAP TYPE/ FREQUENCY)	31/ 33 U/ 17 1/ 8 4/ 8 11/ 8	U/ 38 31/ 23 33/ 15 4/ 8 22/ 8	U/ 56 14/ 22 4/ 11 29/ 11	U/ 40 4/ 20 8/ 10 20/ 10 31/ 10	U/100	2/ 33 4/ 33 U/ 33	2/ 50 4/ 50	4/ 50 31/ 25 U/ 25	4/ 50 U/ 50	4/ 20 11/ 20 31/ 20 6/ 10 8/ 10	U/ 32 31/ 21 4/ 16 14/ 5 15/ 5	U/ 36 2/ 9 4/ 9 6/ 9 8/ 9
MOST FREQUENT DURATION (NUMBER OF 12HR PERIODS/ FREQUENCY	1/ 50 2/ 50	1/ 80 2/ 10 3/ 10	1/100	1/ 89 2/ 11	1/100	1/100	1/100	1/ 67 2/ 33	1/100	1/ 86 2/ 14	1/ 73 2/ 27	1/ 88 2/ 13



****
* MAP TYPE 32 *
****

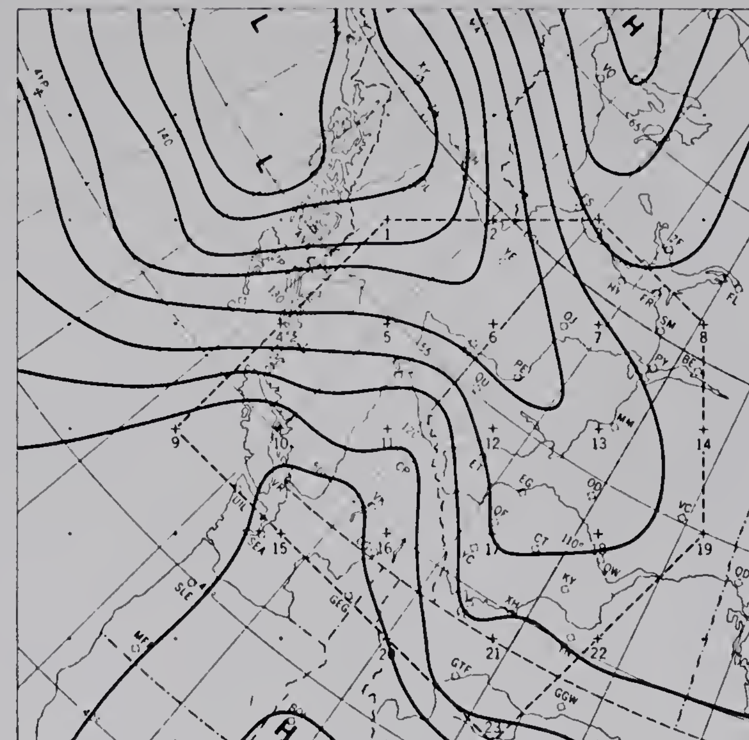
ALBERTA WINDOW
****
PERIOD OF RECORD
1946-1971
****
THIS TYPE
OCCURRED 172 TIMES
DURING THE PERIOD
OF RECORD

CHARACTERISTICS

MONTH	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
NUMBER OF OCCURRENCES	34	22	27	20	7	2	2	6	6	10	18	18
FREQUENCIES OF OCCURRENCES	3	2	2	2	1	0	0	0	1	1	1	1
MAP TYPE MOST FREQUENTLY FOLLOWING (MAP TYPE/ FREQUENCY)	1/ 24 11/ 24 27/ 14 32/ 14 20/ 10	1/ 53 32/ 20 10/ 7 11/ 7 23/ 7	32/ 30 1/ 20 27/ 20 11/ 10 23/ 10	1/ 67 32/ 33	1/ 75 24/ 25	1/ 50 11/ 50	1/ 50 U/ 50	1/ 20 10/ 20 19/ 20 20/ 20 23/ 20	1/ 33 U/ 33 6/ 17 10/ 17	1/ 38 32/ 25 23/ 13 27/ 13 U/ 13	1/ 53 32/ 24 6/ 6 16/ 6 23/ 6	1/ 36 27/ 36 11/ 9 19/ 9 32/ 9
MOST FREQUENT DURATION (NUMBER OF 12HR PERIODS/ FREQUENCY	1/ 89 2/ 6 3/ 6	1/ 82 2/ 18	1/ 86 2/ 7 4/ 7	1/ 67 2/ 17 3/ 17	1/100	1/100	1/100	1/100	1/100	1/ 83 3/ 17	1/ 85 2/ 8 3/ 8	1/ 88 2/ 13

****
* MAP TYPE 33 *
****

ALBERTA WINDOW
****
PERIOD OF RECORD
1946-1971
****
THIS TYPE
OCCURRED 165 TIMES
DURING THE PERIOD
OF RECORD



CHARACTERISTICS

MONTH	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
NUMBER OF OCCURRENCES	12	22	20	24	6	1	0	3	8	20	22	27
FREQUENCIES OF OCCURRENCES	1	2	2	2	0	0	0	0	1	2	2	2
MAP TYPE MOST FREQUENTLY FOLLOWING (MAP TYPE/ FREQUENCY)	2/ 20 3/ 20 9/ 20 15/ 20 24/ 20	3/ 21 22/ 21 U/ 21 4/ 7 9/ 7	33/ 29 31/ 21 U/ 14 2/ 7 3/ 7	31/ 24 33/ 24 3/ 14 9/ 14 2/ 10	3/ 25 9/ 25 33/ 25 U/ 25	4/100		3/100	U/ 40 9/ 20 11/ 20 29/ 20	33/ 20 3/ 13 4/ 13 15/ 13 31/ 13	33/ 21 9/ 16 31/ 16 2/ 11 4/ 11	33/ 32 U/ 21 2/ 16 4/ 11 3/ 5
MOST FREQUENT DURATION (NUMBER OF 12HR PERIODS/ FREQUENCY	1/100	1/ 92 2/ 8	1/ 78 2/ 11 4/ 11	1/ 75 2/ 19 3/ 6	1/ 67 2/ 33	1/100		1/100	1/100	1/ 75 2/ 25	1/ 80 2/ 13 3/ 7	1/ 69 2/ 15 3/ 15

```
*********************
* UNCORRELATED MAPS *
*********************
```

ALBERTA WINDOW
****
PERIOD OF RECORD
1946-1971
****
3836 MAPS WERE
UNCORRELATED
DURING THE PERIOD
OF RECORD

CHARACTERISTICS

MONTH	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
NUMBER OF OCCURRENCES	258	230	281	300	390	412	468	438	334	225	258	242
FREQUENCIES OF OCCURRENCES	21	20	23	25	32	35	38	35	28	18	21	19
MAP TYPE MOST FREQUENTLY FOLLOWING (MAP TYPE/ FREQUENCY)	U/ 40 15/ 6 32/ 5 6/ 4 8/ 4	U/ 41 1/ 6 8/ 6 15/ 5 3/ 4	U/ 37 11/ 7 1/ 6 3/ 5 4/ 5	U/ 51 9/ 4 1/ 3 4/ 3 5/ 3	U/ 55 4/ 6 9/ 5 14/ 5 12/ 4	U/ 61 4/ 6 9/ 4 12/ 3 14/ 3	U/ 63 4/ 9 9/ 4 2/ 3 12/. 3	U/ 56 4/ 7 9/ 6 13/ 4 26/ 4	U/ 42 4/ 6 6/ 5 9/ 4 12/ 4	U/ 39 3/ 9 8/ 8 15/ 7 4/ 6	U/ 43 3/ 7 8/ 7 15/ 6 11/ 5	U/ 40 15/ 7 6/ 6 11/ 6 8/ 5
MOST FREQUENT DURATION (NUMBER OF 12HR PERIODS/ FREQUENCY	1/ 57 2/ 30 3/ 7 4/ 5	1/ 55 2/ 31 3/ 9 4/ 3	1/ 68 2/ 19 3/ 5 4/ 4	1/ 50 2/ 26 3/ 11 4/ 7	1/ 47 2/ 28 3/ 13 5/ 6	1/ 42 2/ 25 3/ 12 4/ 8	1/ 37 2/ 27 3/ 15 4/ 6	1/ 43 2/ 29 3/ 12 5/ 6	1/ 57 2/ 29 3/ 7 5/ 4	1/ 62 2/ 27 3/ 6 5/ 3	1/ 62 2/ 27 3/ 5 5/ 3	1/ 63 2/ 17 3/ 12 4/ 7

APPENDIX 3

SUMMER 500 MB. MAP TYPE AREA AND STATION HEIGHT VALUES

The 500 mb. map typing window is illustrated in Figure 7, and consists of nineteen irregularly spaced rawinsonde stations. The date and station height values for each map type are given in Table 18. The station height values are expressed in decameters (i.e., 58 signifies 5,580 meters .

FIGURE 7.
500 MB. MAP TYPE AREA
NUMBERED STATIONS
REFER TO THE ORDER
IN WHICH THE HEIGHT
VALUES (DKM.) ARE
LISTED IN TABLE
(SEE BELOW).

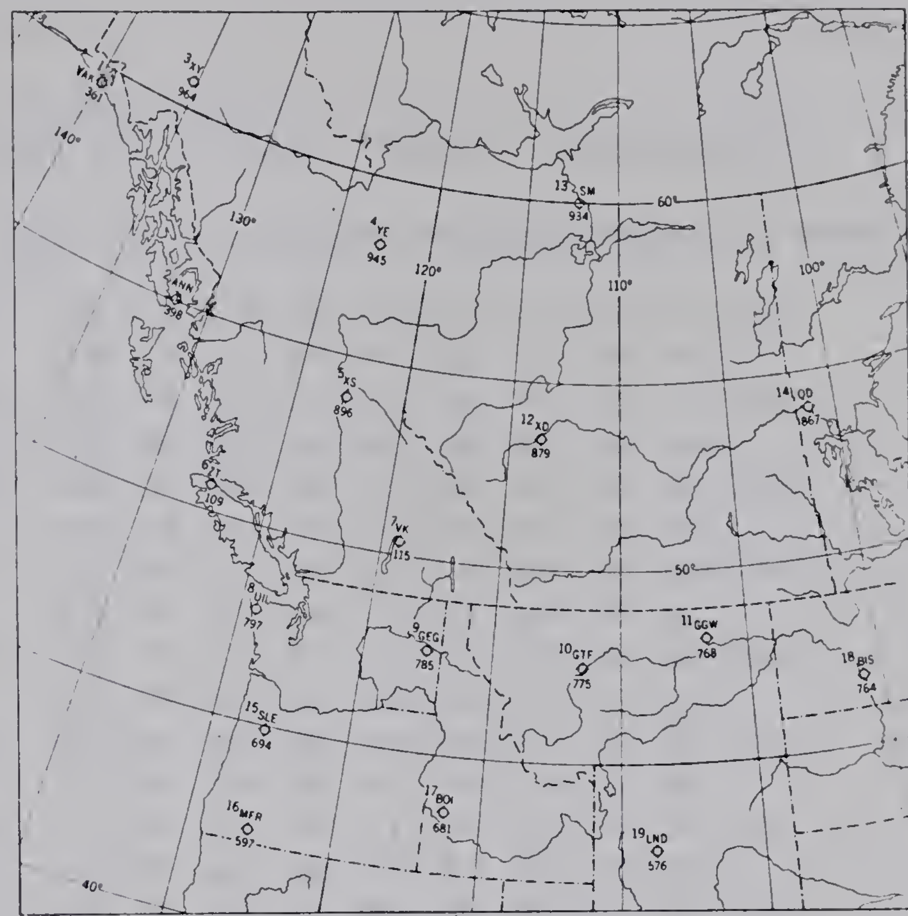


TABLE 18. 500 MB. STATION HEIGHT VALUES

MAP TYPE	DATE	500 MB. STATION HEIGHT VALUES (DKM.)
1	6 JUL 67 12Z	52 55 52 51 58 61 67 69 74 77
		76 63 53 60 77 81 81 79 88
2	27 JUL 67 12Z	54 70 57 63 73 77 78 79 79 77
		73 71 60 59 80 85 82 75 86
3	18 JUL 64 12Z	62 60 62 62 60 57 66 62 75 84
		88 70 65 76 71 78 82 90 91
4	23 JUL 68 12Z	74 76 72 69 71 75 72 76 77 77
		76 69 60 62 81 85 84 80 86
5	24 JUN 63 12Z	38 44 37 49 61 61 68 68 65 71
		75 66 63 75 69 71 65 89 76
6	26 JUL 71 12Z	77 83 79 77 83 87 84 82 84 80
		73 76 63 59 87 88 87 66 84
7	25 JUL 66 12Z	75 73 71 68 66 67 62 63 66 79
		87 68 67 72 73 78 81 88 89
8	19 JUL 70 12Z	49 63 53 71 74 70 82 79 86 85
		84 76 77 76 84 88 90 78 91
9	2 JUL 66 12Z	61 70 65 67 67 67 64 59 65 75
		78 71 68 76 5[illegible] 59 69 82 83
10	12 JUN 69 12Z	79 82 76 72 74 79 73 76 72 66
		59 60 61 41 76 75 71 58 69
11	13 JUN 66 12Z	55 57 59 58 60 63 66 70 72 69
		65 60 57 58 79 86 82 62 76
12	13 JUN 68 12Z	65 55 63 59 56 50 55 52 57 64
		65 54 48 48 59 69 68 72 75

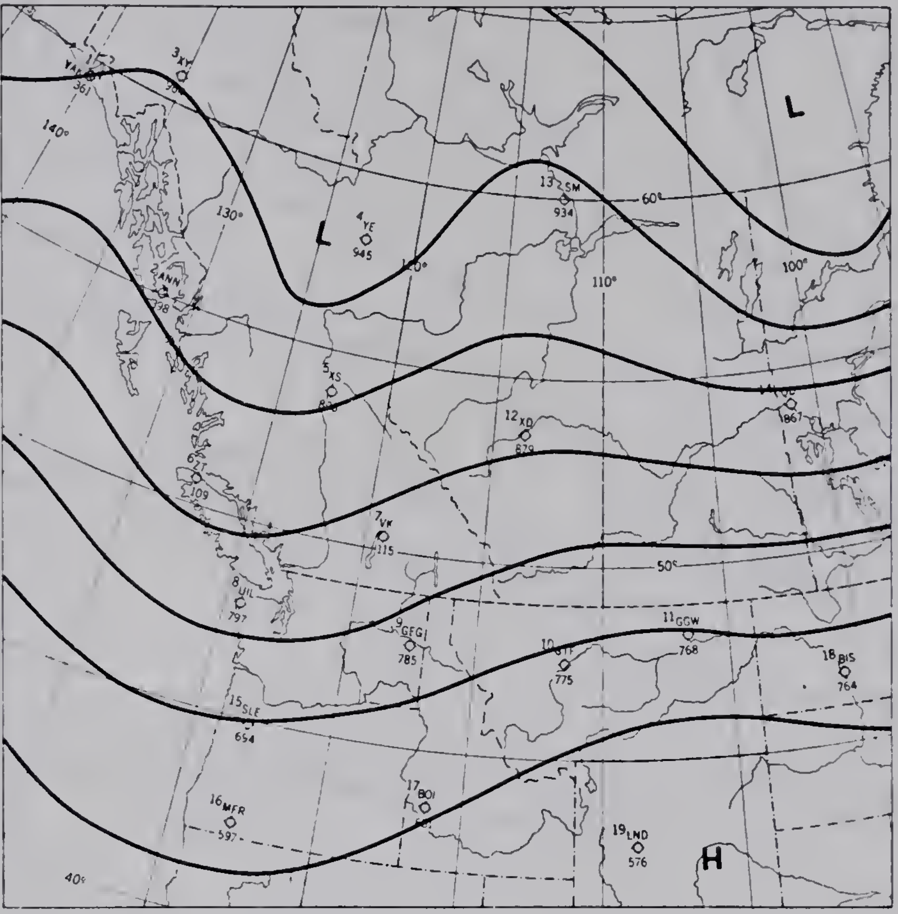
TABLE 18. 500 MB. STATION HEIGHT VALUES (CONTINUED)

MAP TYPE	DATE	500 MB. STATION HEIGHT VALUES (DKM.)
13	17 JUN 65 12Z	46 64 48 68 75 77 73 73 71 69 78 77 71 83 71 67 65 86 71
14	4 SEP 68 0Z	66 78 61 57 71 82 74 83 74 65 59 59 56 53 86 89 78 64 68
15	15 SEP 69 0Z	56 59 53 54 55 62 57 64 59 60 64 49 55 58 71 76 72 74 77
16	22 MAY 71 12Z	43 58 43 52 63 70 68 73 65 59 63 62 53 52 72 71 59 65 61
17	4 JUN 67 0Z	73 75 68 61 66 71 63 67 63 66 63 57 50 51 68 71 70 71 77
18	24 MAY 69 12Z	62 61 62 65 66 57 71 62 74 75 72 69 56 53 67 70 79 67 81
19	2 JUL 64 12Z	57 66 57 66 71 67 73 67 74 80 80 72 65 63 67 70 79 79 87
20	15 SEP 67 12Z	52 77 56 81 88 87 90 87 87 82 73 88 76 75 85 85 84 62 78
21	21 AUG 68 12Z	50 67 53 59 62 65 59 62 60 68 75 61 61 68 61 62 65 82 76
22	29 MAY 67 12Z	47 44 52 57 52 40 55 45 58 63 66 63 64 66 52 58 62 69 64
23	5 JUN 67 12Z	58 70 61 60 69 75 71 71 66 70 71 64 50 56 68 68 69 74 76
24	24 AUG 63 12Z	77 75 77 68 71 69 68 64 69 79 77 66 62 71 61 67 76 81 83
25	9 MAY 71 0Z	39 45 38 39 50 59 60 64 62 60 64 54 29 63 67 64 63 68 62
26	11 JUN 68 0Z	55 51 60 64 60 52 64 61 70 69 66 66 62 64 67 71 76 64 72
27	12 JUL 65 0Z	72 77 75 70 71 72 66 70 68 73 78 66 60 68 70 73 74 84 83
28	9 JUN 65 0Z	56 63 62 65 72 67 73 70 74 76 69 67 52 41 73 73 75 65 78
29	26 MAY 65 12Z	58 68 57 65 70 73 68 70 67 55 51 62 57 50 71 72 65 45 57
30	8 JUL 69 0Z	60 74 60 64 71 76 71 76 71 68 70 65 65 72 76 78 74 77 79
31	7 MAY 66 12Z	52 61 59 70 69 62 64 66 66 70 72 67 67 57 72 75 78 72 82
32	11 SEP 70 12Z	80 70 73 56 55 68 61 73 63 59 60 50 50 46 79 85 77 66 77
33	22 JUL 70 12Z	61 70 61 53 63 72 63 71 64 71 77 65 50 71 73 77 74 81 81
34	30 JUN 68 0Z	74 74 73 73 71 74 66 71 63 57 58 63 66 56 71 76 64 69 64
35	16 AUG 63 12Z	78 72 76 77 73 71 75 74 78 80 76 70 73 70 80 85 85 78 87

APPENDIX 4

SUMMER 500 MB. MAP TYPES AND CHARACTERISTICS

The 500 mb. contour maps in this Appendix represent the contour patterns associated with the map types. The window is contained within the numbered stations. The characteristics of each map type are summarized by month. The number of occurrences indicates the number of times the contour pattern occurred during each month for the entire period of record (May - September 1963-1971). The frequency of occurrences gives the percentage of time that the map type occurred during the month. The next set of data indicates the map types which most frequently followed the given type and the corresponding percentage. Finally, the duration of the map type is indicated by the number of twelve-hour periods that the map type persisted, and the corresponding percentage.



****
*   500 MB.   *
* MAP TYPE 1 *
****

****
PERIOD OF RECORD
1963-1971
****
THIS TYPE
OCCURRED 525 TIMES
DURING THE PERIOD
OF RECORD

CHARACTERISTICS

MONTH	MAY	JUNE	JULY	AUG	SEPT
NUMBER OF OCCURRENCES	91	81	132	119	102
FREQUENCIES OF OCCURRENCES	16	15	24	21	19
MAP TYPE MOST	1/ 62	1/ 63	1/ 67	1/ 67	1/ 64
FREQUENTLY	3/ 13	3/ 14	3/ 9	2/ 8	3/ 13
FOLLOWING	2/ 6	2/ 5	2/ 4	3/ 5	2/ 10
(MAP TYPE/	15/ 4	5/ 5	4/ 4	25/ 5	4/ 3
FREQUENCY)	25/ 4	4/ 4	25/ 3	4/ 4	8/ 3
MOST FREQUENT	1/ 34	2/ 29	1/ 36	1/ 46	1/ 44
DURATION (NUMBER	2/ 31	3/ 29	2/ 22	2/ 13	2/ 26
OF 12HR PERIODS/	3/ 11	1/ 26	3/ 13	5/ 10	3/ 8
FREQUENCY)	4/ 9	6/ 6	4/ 7	4/ 8	4/ 8

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***************
*   500 MB.   *
* MAP TYPE  2 *
***************
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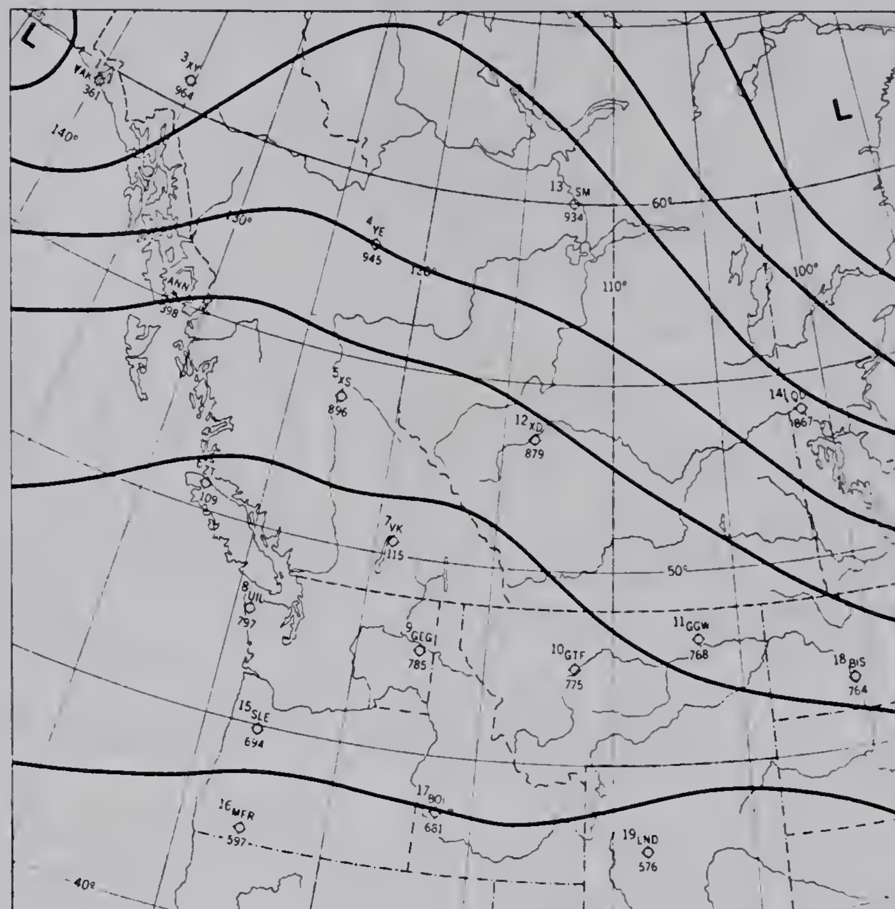
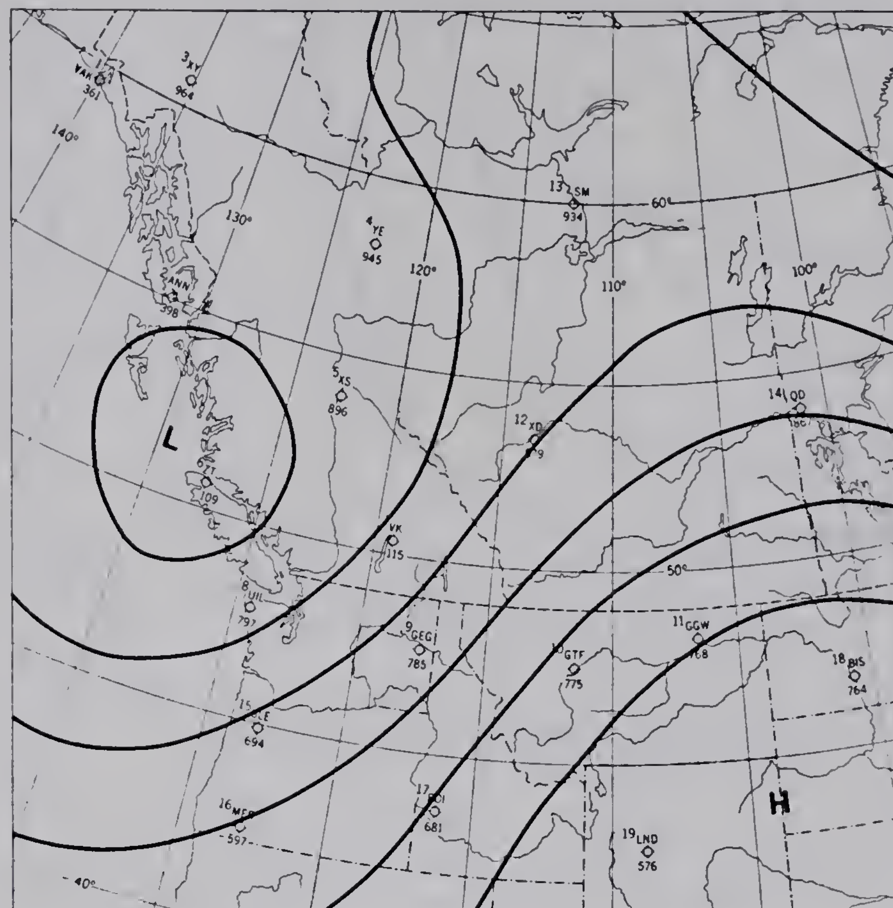
****
PERIOD OF RECORD
1963-1971
****
THIS TYPE
OCCURRED 385 TIMES
DURING THE PERIOD
OF RECORD



CHARACTERISTICS

MONTH	MAY	JUNE	JULY	AUG	SEPT
NUMBER OF OCCURRENCES	72	45	93	80	95
FREQUENCIES OF OCCURRENCES	13	8	17	14	18
MAP TYPE MOST	2/ 64	2/ 60	2/ 70	2/ 59	2/ 61
FREQUENTLY	1/ 15	8/ 18	1/ 13	1/ 13	1/ 13
FOLLOWING	8/ 8	1/ 11	8/ 7	8/ 10	8/ 6
(MAP TYPE/	6/ 3	16/ 4	11/ 3	28/ 4	11/ 5
FREQUENCY)	11/ 3	4/ 2	4/ 2	4/ 3	4/ 3
MOST FREQUENT	1/ 31	1/ 56	2/ 31	1/ 44	1/ 50
DURATION (NUMBER	2/ 31	2/ 11	1/ 2[illegible]	3/ 21	2/ 13
OF 12HR PERIODS/	5/ 12	3/ 11	5/ 17	2/ 18	3/ 11
FREQUENCY)	3/ 8	8/ 11	3/ 10	4/ 6	4/ 11

****
*   500 MB.   *
* MAP TYPE 3 *
****



****

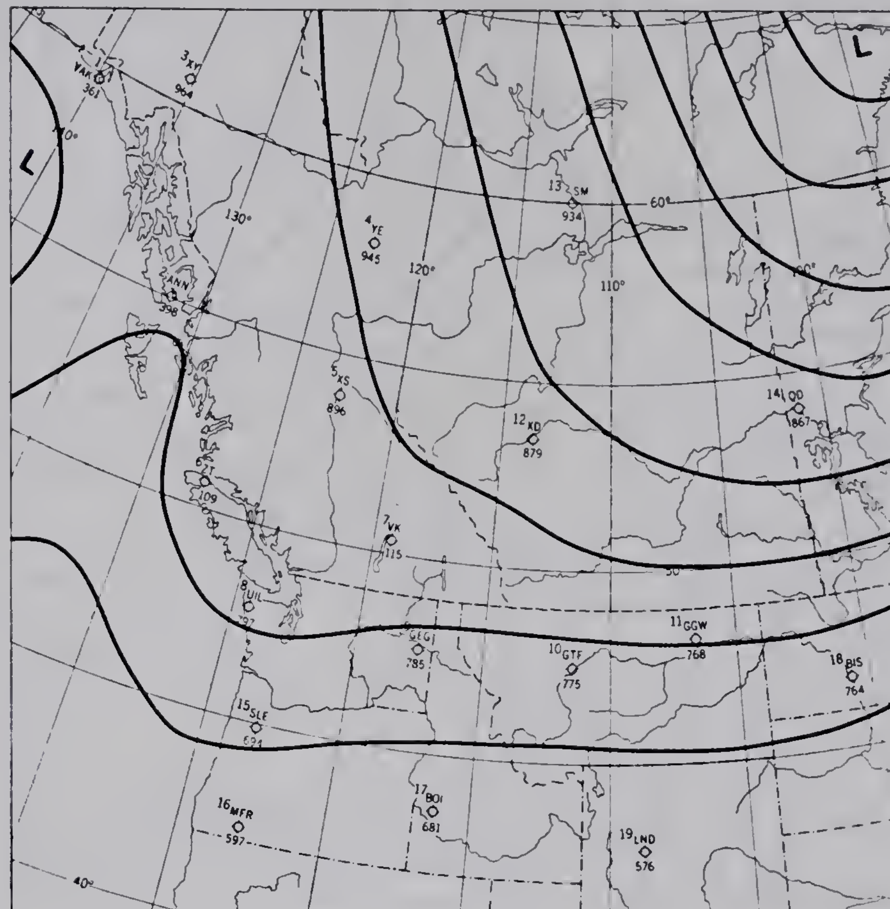
PERIOD OF RECORD
1963-1971

****

THIS TYPE
OCCURRED 249 TIMES
DURING THE PERIOD
OF RECORD

CHARACTERISTICS

MONTH	MAY	JUNE	JULY	AUG	SEPT
NUMBER OF OCCURRENCES	42	49	65	59	34
FREQUENCIES OF OCCURRENCES	8	9	12	11	6
MAP TYPE MOST	3/ 52	3/ 67	3/ 67	3/ 68	3/ 48
FREQUENTLY	7/ 12	U/ 10	1/ 13	15/ 10	7/ 15
FOLLOWING	1/ 10	1/ 4	7/ 8	1/ 8	15/ 9
(MAP TYPE/	15/ 10	7/ 4	15/ 3	U/ 5	21/ 6
FREQUENCY)	U/ 10	5/ 2	21/ 3	7/ 3	33/ 6
MOST FREQUENT	1/ 55	2/ 29	1/ 32	3/ 32	2/ 44
DURATION (NUMBER	2/ 20	1/ 24	2/ 32	1/ 21	1/ 39
OF 12HR PERIODS/	3/ 10	3/ 24	3/ 9	2/ 21	3/ 11
FREQUENCY)	6/ 10	5/ 12	8/ 9	4/ 11	5/ 6

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***************
*   500 MB.   *
* MAP TYPE  4 *
***************
```

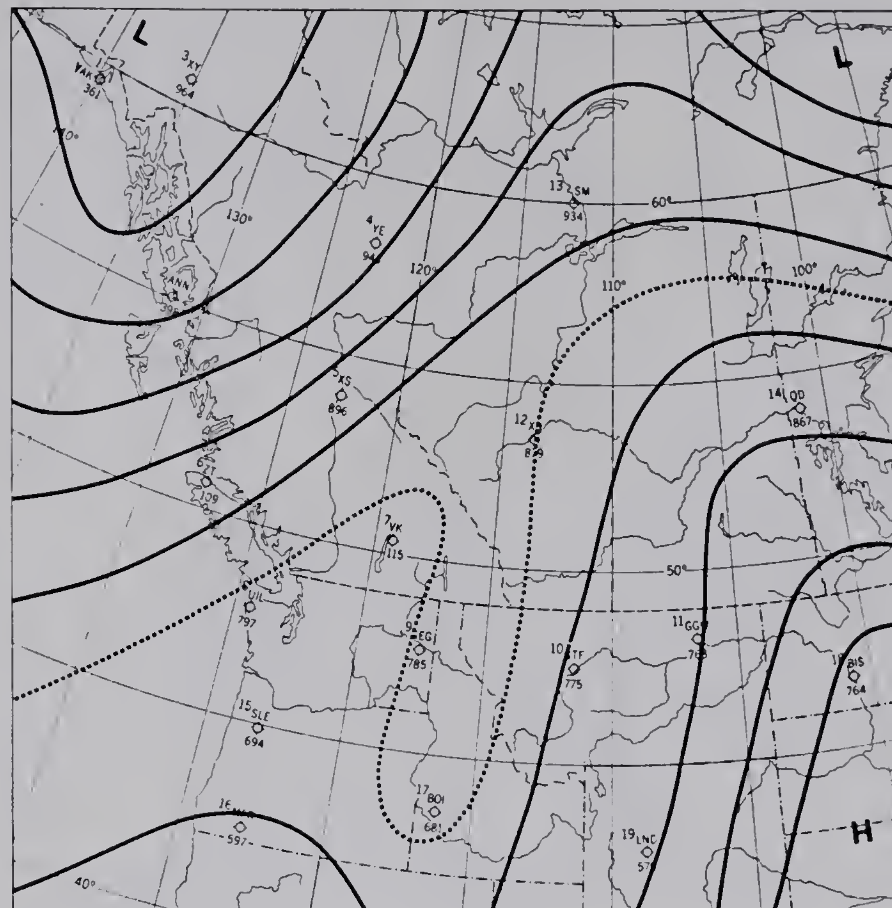
****
PERIOD OF RECORD
1963-1971
****
THIS TYPE
OCCURRED 126 TIMES
DURING THE PERIOD
OF RECORD

CHARACTERISTICS

MONTH	MAY	JUNE	JULY	AUG	SEPT
NUMBER OF OCCURRENCES	14	16	45	35	16
FREQUENCIES OF OCCURRENCES	3	3	8	6	3
MAP TYPE MOST	4/ 71	4/ 40	4/ 60	4/ 49	4/ 38
FREQUENTLY	2/ 7	2/ 20	2/ 12	2/ 23	14/ 19
FOLLOWING	12/ 7	1/ 13	1/ 5	6/ 6	1/ 6
(MAP TYPE/	17/ 7	14/ 7	18/ 5	18/ 6	2/ 6
FREQUENCY)	U/ 7	15/ 7	28/ 5	23/ 6	11/ 6
MOST FREQUENT	1/ 25	1/ 70	1/ 47	1/ 39	1/ 60
DURATION (NUMBER	3/ 25	2/ 20	2/ 21	2/ 33	2/ 30
OF 12HR PERIODS/	4/ 25	5/ 10	3/ 21	3/ 22	4/ 10
FREQUENCY)	6/ 25		5/ 5	4/ 6	

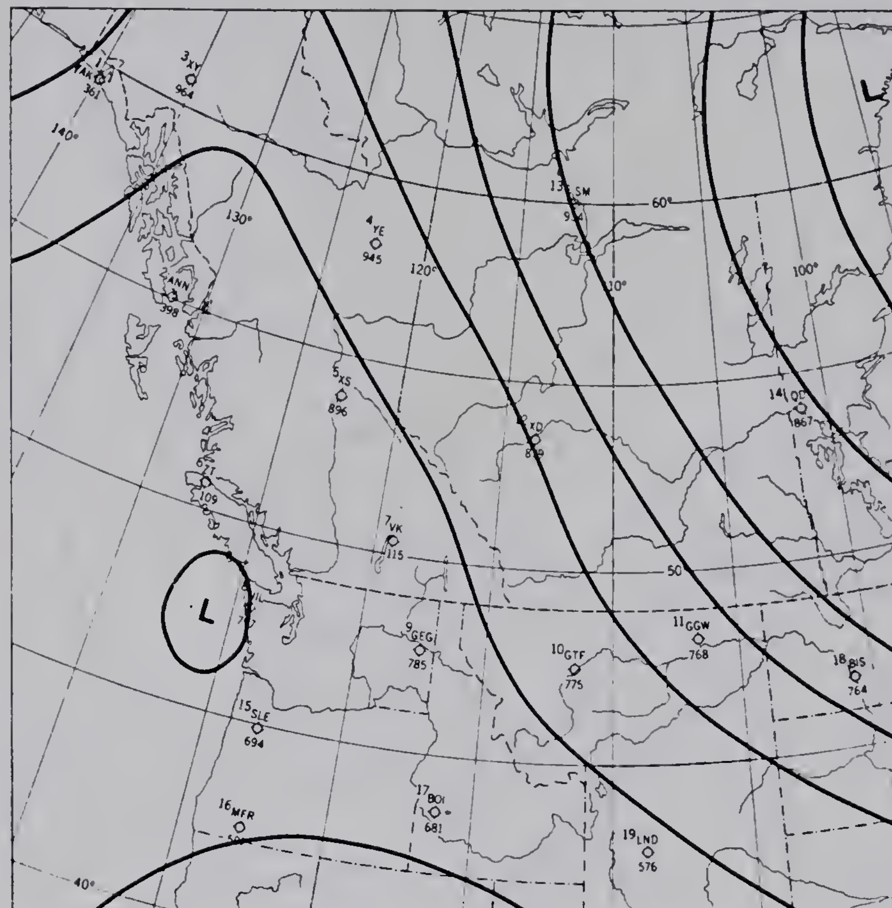
****
*   500 MB.   *
* MAP TYPE 5 *
****

****
PERIOD OF RECORD
1963-1971
****
THIS TYPE
OCCURRED   58 TIMES
DURING THE PERIOD
OF RECORD



CHARACTERISTICS

MONTH	MAY	JUNE	JULY	AUG	SEPT
NUMBER OF OCCURRENCES	9	28	4	4	13
FREQUENCIES OF OCCURRENCES	2	5	1	1	2
MAP TYPE MOST	5/ 44	5/ 43	5/ 50	5/ 50	5/ 62
FREQUENTLY	25/ 22	U/ 21	8/ 25	3/ 25	1/ 15
FOLLOWING	1/ 11	1/ 7	30/ 25	8/ 25	25/ 15
(MAP TYPE/	8/ 11	3/ 7			8/ 8
FREQUENCY)	U/ 11	25/ 7			
MOST FREQUENT	1/ 40	1/ 63	1/ 50	2/100	2/ 40
DURATION (NUMBER	2/ 40	2/ 19	3/ 50		1/ 20
OF 12HR PERIODS/	3/ 20	3/ 6			3/ 20
FREQUENCY)		4/ 6			5/ 20



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***************
*   500 MB.   *
* MAP TYPE  6 *
***************
```

****

PERIOD OF RECORD
1963-1971

****

THIS TYPE
OCCURRED 65 TIMES
DURING THE PERIOD
OF RECORD

CHARACTERISTICS

MONTH	MAY	JUNE	JULY	AUG	SEPT
NUMBER OF OCCURRENCES	21	10	14	10	10
FREQUENCIES OF OCCURRENCES	4	2	3	2	2
MAP TYPE MOST FREQUENTLY FOLLOWING (MAP TYPE/ FREQUENCY)	6/ 62 U/ 14 28/ 10 11/ 5 16/ 5	6/ 50 28/ 40 U/ 10	6/ 71 2/ 14 28/ 7 29/ 7	6/ 67 28/ 22 U/ 11	6/ 40 2/ 30 14/ 10 28/ 10 U/ 10
MOST FREQUENT DURATION (NUMBER OF 12HR PERIODS/ FREQUENCY)	1/ 38 2/ 25 3/ 25 8/ 13	1/ 40 2/ 40 4/ 20	1/ 25 2/ 25 3/ 25 8/ 25	1/ 25 2/ 25 3/ 25 4/ 25	1/ 67 2/ 17 4/ 17

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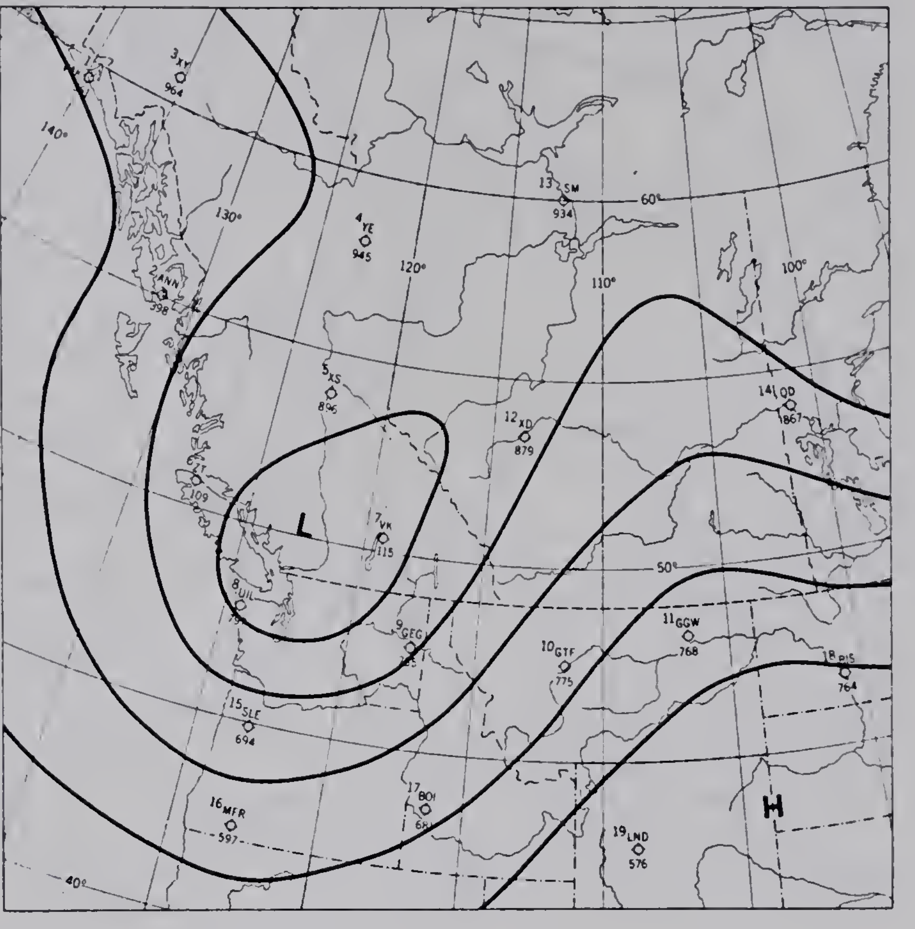
***************
*   500 MB.   *
* MAP TYPE  7 *
***************
```



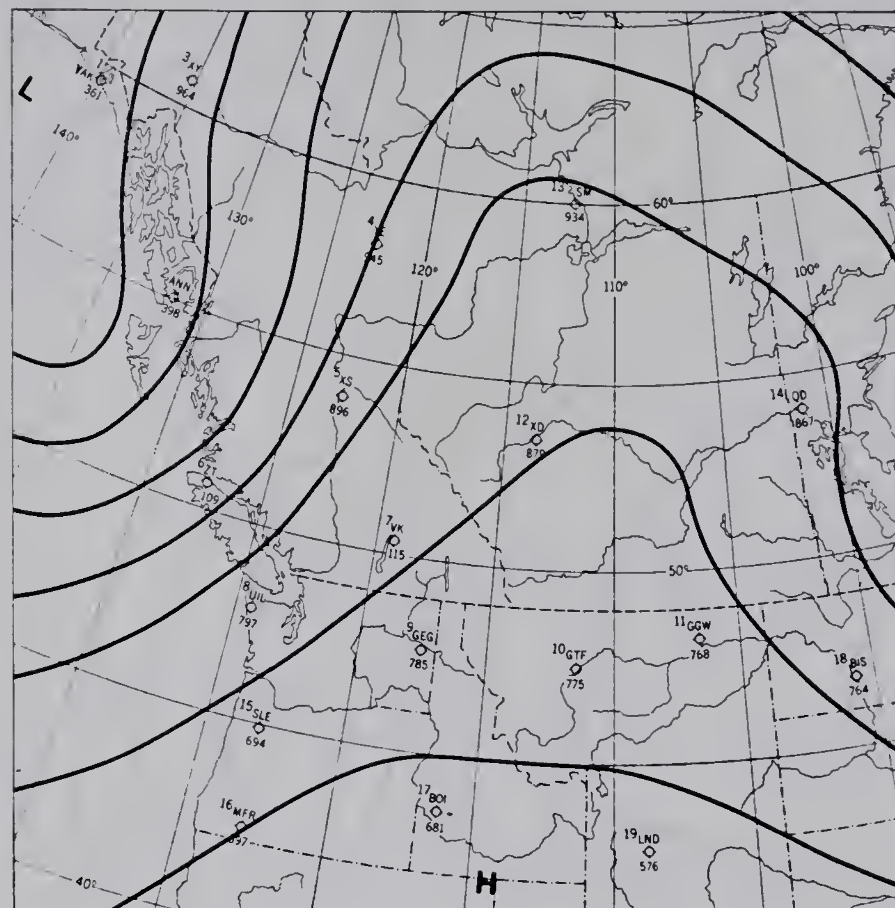
****
PERIOD OF RECORD
1963–1971
****
THIS TYPE
OCCURRED 40 TIMES
DURING THE PERIOD
OF RECORD

CHARACTERISTICS

MONTH	MAY	JUNE	JULY	AUG	SEPT
NUMBER OF OCCURRENCES	5	4	21	3	7
FREQUENCIES OF OCCURRENCES	1	1	4	1	1
MAP TYPE MOST	27/ 40	U/ 50	7/ 43	7/ 33	21/ 29
FREQUENTLY	U/ 40	7/ 25	15/ 14	27/ 33	U/ 29
FOLLOWING	1/ 20	27/ 25	4/ 10	33/ 33	7/ 14
(MAP TYPE/			27/ 10		9/ 14
FREQUENCY)			9/ 5		27/ 14
MOST FREQUENT	1/100	1/ 67	1/ 58	1/ 50	1/ 83
DURATION (NUMBER		2/ 33	2/ 17	2/ 50	2/ 17
OF 12HR PERIODS/			3/ 17		
FREQUENCY)			4/ 8		

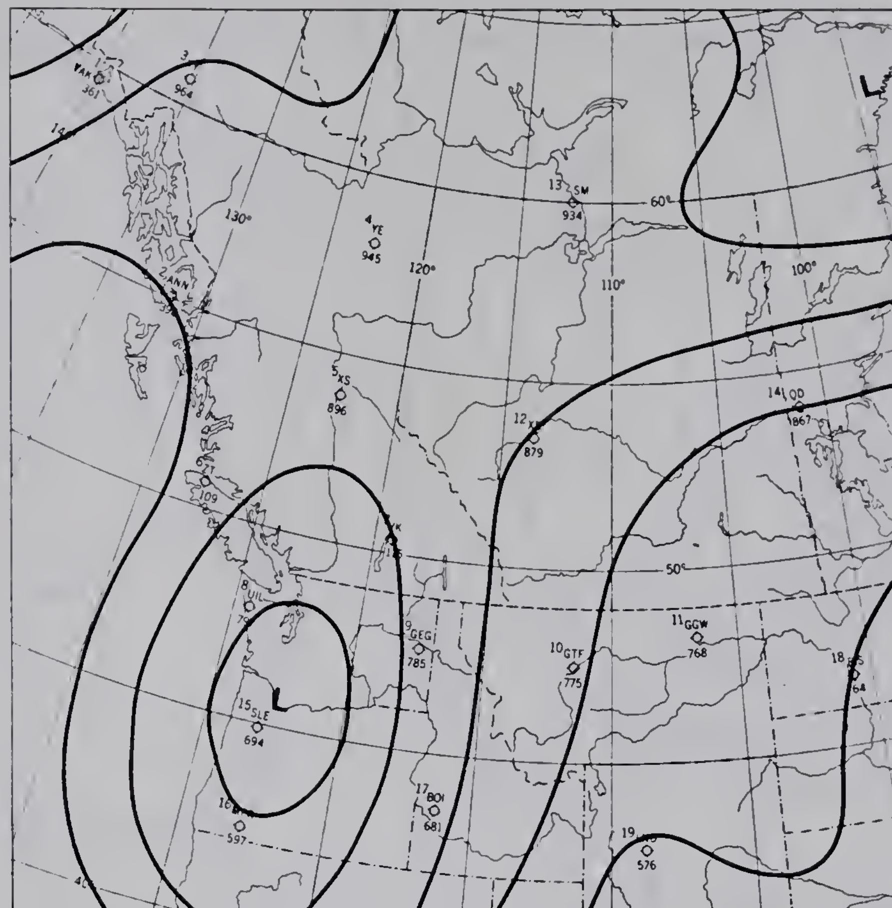
****
*   500 MB.   *
* MAP TYPE 8 *
****

****
PERIOD OF RECORD
1963-1971
****
THIS TYPE
OCCURRED 187 TIMES
DURING THE PERIOD
OF RECORD



CHARACTERISTICS

MONTH	MAY	JUNE	JULY	AUG	SEPT
NUMBER OF OCCURRENCES	38	29	36	52	32
FREQUENCIES OF OCCURRENCES	7	5	6	9	6
MAP TYPE MOST	8/ 53	8/ 59	8/ 67	8/ 67	8/ 53
FREQUENTLY	1/ 18	1/ 28	1/ 19	1/ 22	1/ 28
FOLLOWING	22/ 8	5/ 10	2/ 3	3/ 8	5/ 9
(MAP TYPE/	25/ 5	2/ 3	3/ 3	26/ 4	3/ 6
FREQUENCY)	26/ 5		19/ 3		25/ 3
MOST FREQUENT	2/ 39	1/ 42	2/ 33	1/ 28	1/ 47
DURATION (NUMBER	1/ 28	2/ 25	3/ 2[illegible]	3/ 22	3/ 20
OF 12HR PERIODS/	3/ 28	3/ 8	1/ 17	2/ 17	4/ 20
FREQUENCY)	4/ 6	4/ 8	6/ 17	5/ 17	2/ 13



****
*   500 MB.   *
* MAP TYPE 9 *
****

****
PERIOD OF RECORD
1963-1971
****
THIS TYPE
OCCURRED 19 TIMES
DURING THE PERIOD
OF RECORD

CHARACTERISTICS

MONTH	MAY	JUNE	JULY	AUG	SEPT
NUMBER OF OCCURRENCES	2	5	9	1	2
FREQUENCIES OF OCCURRENCES	0	1	2	0	0
MAP TYPE MOST FREQUENTLY FOLLOWING (MAP TYPE/ FREQUENCY)	U/100	9/ 60 3/ 20 24/ 20	9/ 56 22/ 22 19/ 11 21/ 11	21/100	21/ 50 U/ 50
MOST FREQUENT DURATION (NUMBER OF 12HR PERIODS/ FREQUENCY)	1/100	1/ 50 4/ 50	3/ 50 1/ 25 2/ 25	1/100	1/100

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***************
*    500 MB.   *
* MAP TYPE 10 *
***************
```
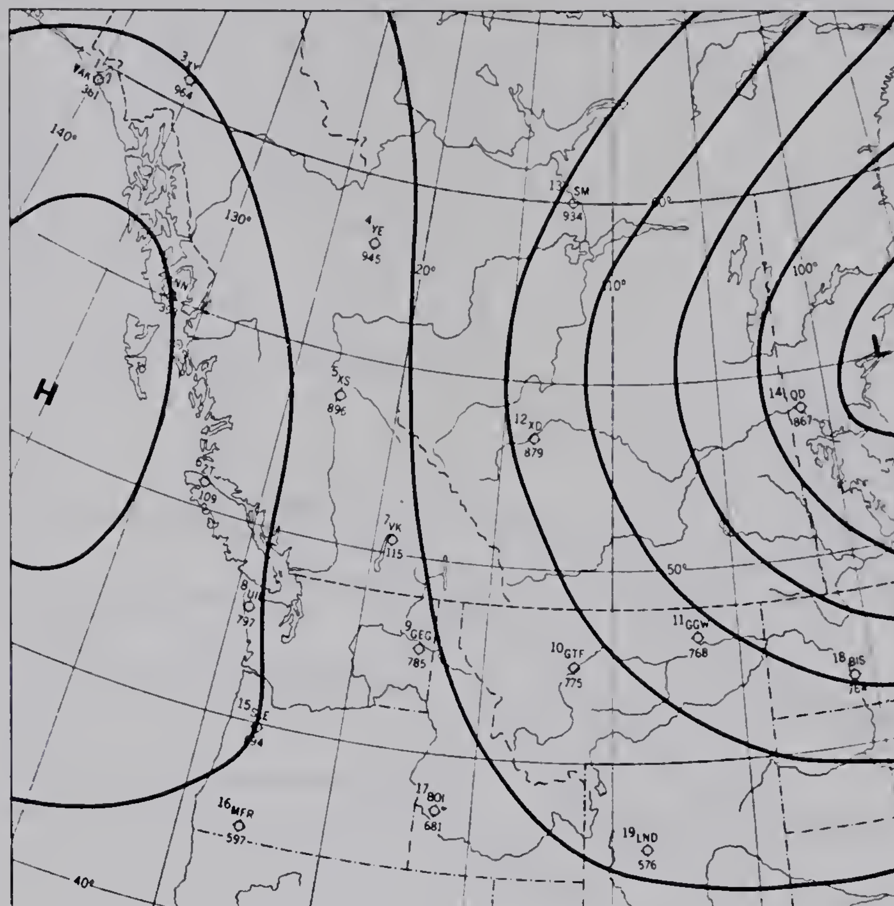



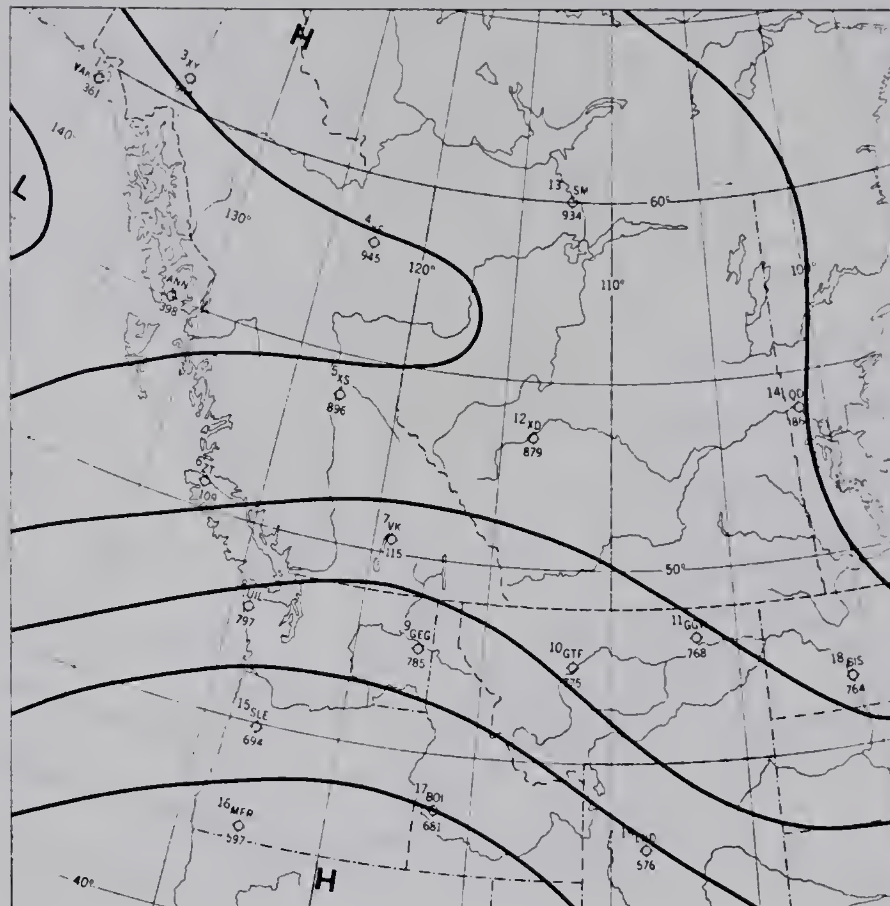
****
PERIOD OF RECORD
1963-1971
****
THIS TYPE
OCCURRED 27 TIMES
DURING THE PERIOD
OF RECORD

CHARACTERISTICS

MONTH	MAY	JUNE	JULY	AUG	SEPT
NUMBER OF OCCURRENCES	7	14	0	0	6
FREQUENCIES OF OCCURRENCES	1	3	0	0	1
MAP TYPE MOST FREQUENTLY FOLLOWING (MAP TYPE/ FREQUENCY)	10/ 71 6/ 14 U/ 14	10/ 79 U/ 14 14/ 7			6/ 33 10/ 33 14/ 17 17/ 17
MOST FREQUENT DURATION (NUMBER OF 12HR PERIODS/ FREQUENCY)	1/ 50 6/ 50	2/ 33 3/ 33 9/ 33			1/ 50 2/ 50

****
*   500 MB.   *
* MAP TYPE 11 *
****

****
PERIOD OF RECORD
1963-1971
****
THIS TYPE
OCCURRED 75 TIMES
DURING THE PERIOD
OF RECORD



CHARACTERISTICS

MONTH	MAY	JUNE	JULY	AUG	SEPT
NUMBER OF OCCURRENCES	16	23	5	10	21
FREQUENCIES OF OCCURRENCES	3	4	1	2	4
MAP TYPE MOST	2/ 20	11/ 73	1/ 40	11/ 50	11/ 43
FREQUENTLY	11/ 20	1/ 9	2/ 40	U/ 20	1/ 24
FOLLOWING	1/ 13	2/ 9	8/ 20	1/ 10	14/ 10
(MAP TYPE/	14/ 13	8/ 5		8/ 10	2/ 5
FREQUENCY)	4/ 7	26/ 5		18/ 10	4/ 5
MOST FREQUENT	1/ 77	1/ 57	1/100	2/ 60	1/ 58
DURATION (NUMBER	2/ 23	4/ 14		1/ 20	2/ 25
OF 12HR PERIODS/		7/ 14		3/ 20	3/ 8
FREQUENCY)		8/ 14			5/ 8

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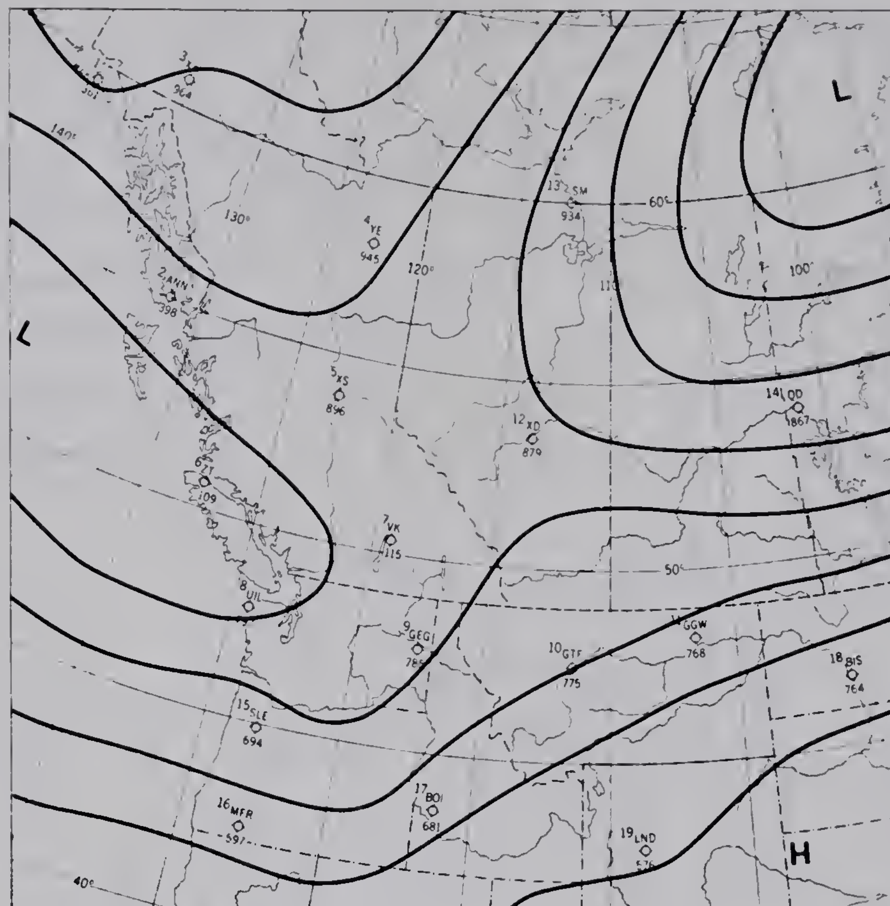
***************
*   500 MB.   *
* MAP TYPE 12 *
***************
```



****

PERIOD OF RECORD
1963-1971

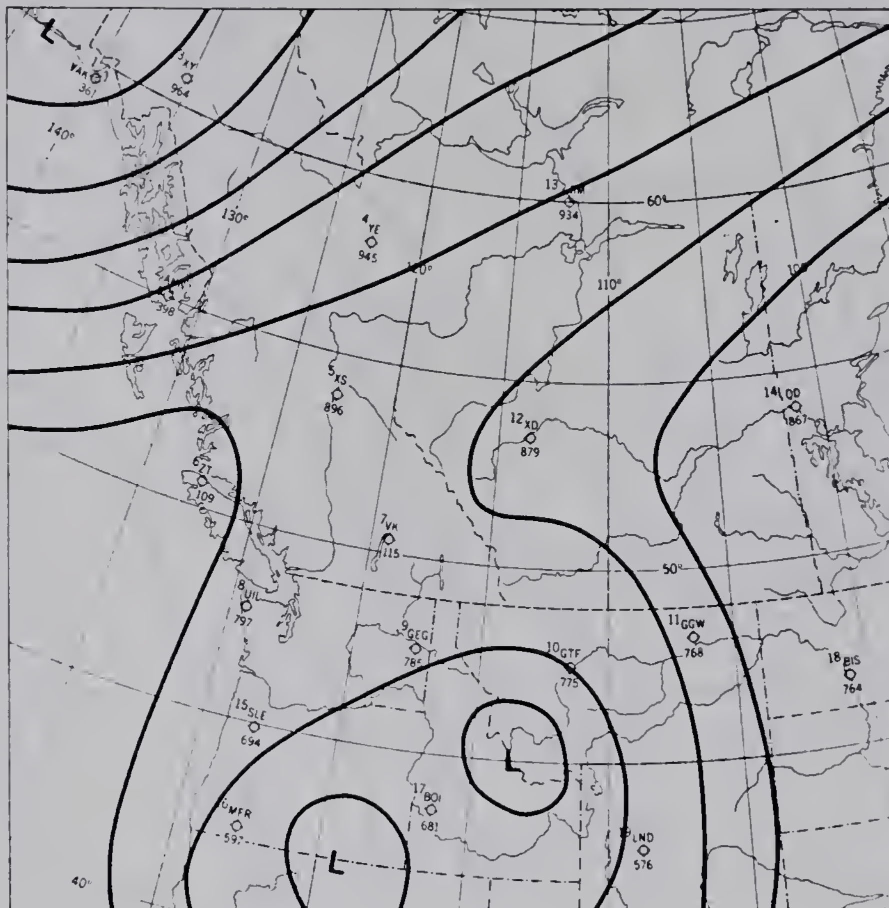
****

THIS TYPE
OCCURRED 28 TIMES
DURING THE PERIOD
OF RECORD

CHARACTERISTICS

MONTH	MAY	JUNE	JULY	AUG	SEPT
NUMBER OF OCCURRENCES	6	3	11	6	2
FREQUENCIES OF OCCURRENCES	1	1	2	1	0
MAP TYPE MOST FREQUENTLY FOLLOWING (MAP TYPE/ FREQUENCY)	12/ 50 1/ 17 27/ 17 U/ 17	12/ 33 15/ 33 35/ 33	12/ 36 3/ 18 7/ 18 U/ 18 4/ 9	U/ 50 12/ 33 4/ 17	7/ 50 12/ 50
MOST FREQUENT DURATION (NUMBER OF 12HR PERIODS/ FREQUENCY)	1/ 33 2/ 33 3/ 33	1/ 50 2/ 50	2/ 57 1/ 43	1/ 75 3/ 25	2/100

****
*   500 MB.   *
* MAP TYPE 13 *
****



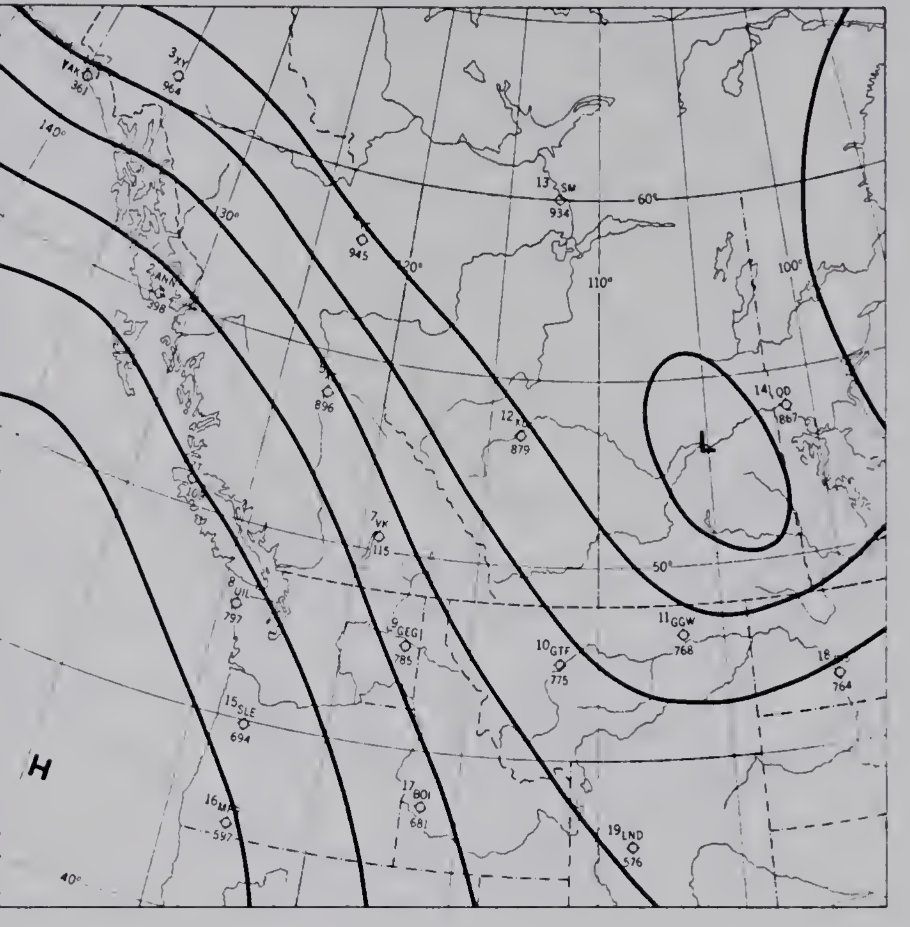
****
PERIOD OF RECORD
1963-1971
****
THIS TYPE
OCCURRED 15 TIMES
DURING THE PERIOD
OF RECORD

CHARACTERISTICS

MONTH	MAY	JUNE	JULY	AUG	SEPT
NUMBER OF OCCURRENCES	0	14	0	0	1
FREQUENCIES OF OCCURRENCES	0	3	0	0	0
MAP TYPE MOST FREQUENTLY FOLLOWING (MAP TYPE/ FREQUENCY)		13/ 50 5/ 29 U/ 21			U/100
MOST FREQUENT DURATION (NUMBER OF 12HR PERIODS/ FREQUENCY)		1/ 43 2/ 43 5/ 14			1/100

****
* 500 MB. *
* MAP TYPE 14 *
****

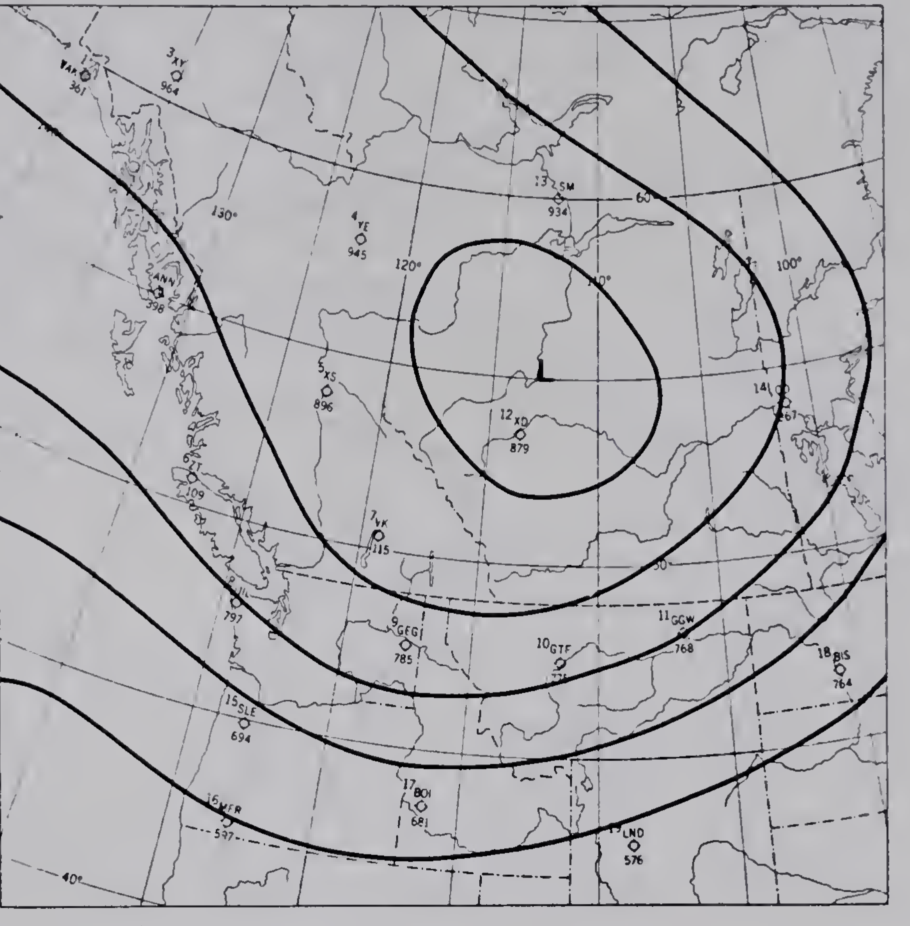
****
PERIOD OF RECORD
1963-1971
****
THIS TYPE
OCCURRED 59 TIMES
DURING THE PERIOD
OF RECORD



CHARACTERISTICS

MONTH	MAY	JUNE	JULY	AUG	SEPT
NUMBER OF OCCURRENCES	12	6	1	9	31
FREQUENCIES OF OCCURRENCES	2	1	0	2	6
MAP TYPE MOST	14/ 36	6/ 33	6/100	14/ 67	14/ 70
FREQUENTLY	2/ 18	14/ 33		2/ 11	2/ 10
FOLLOWING	11/ 18	2/ 17		6/ 11	6/ 10
(MAP TYPE/	6/ 9	U/ 17		U/ 11	10/ 3
FREQUENCY)	16/ 9				29/ 3
MOST FREQUENT	1/ 63	1/ 75	1/100	2/ 67	2/ 30
DURATION (NUMBER	2/ 25	3/ 25		5/ 33	1/ 20
OF 12HR PERIODS/	3/ 13				3/ 20
FREQUENCY)					4/ 10

****
*   500 MB.   *
* MAP TYPE 15 *
****

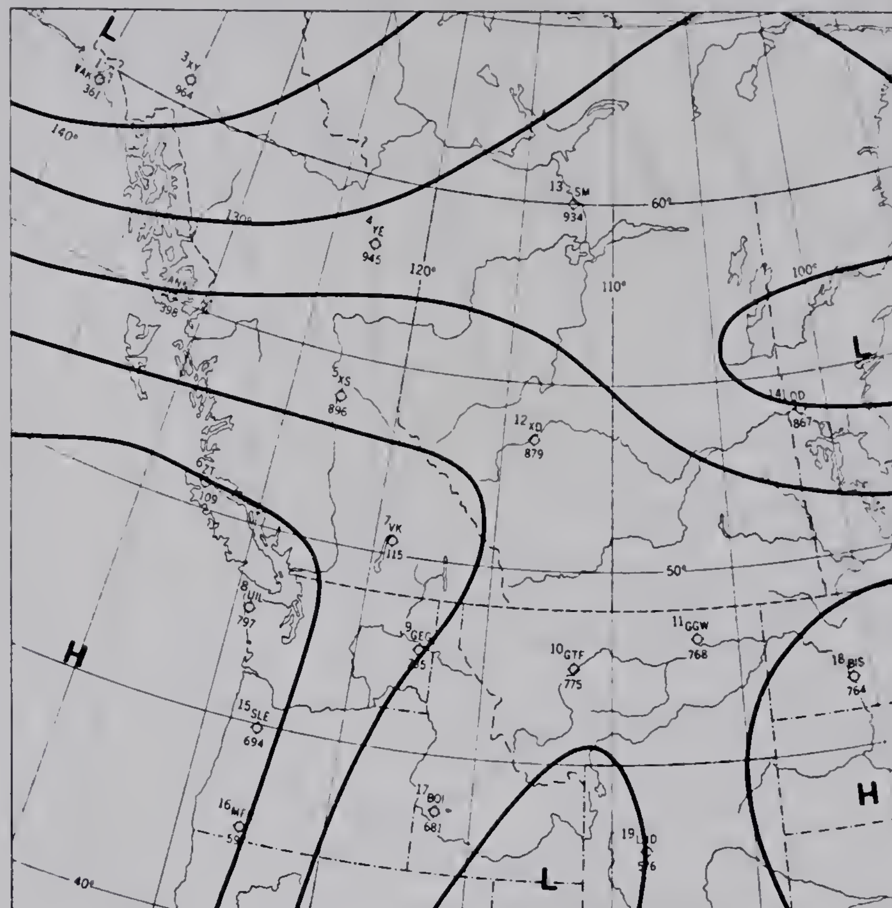


****
PERIOD OF RECORD
1963-1971
****
THIS TYPE
OCCURRED 66 TIMES
DURING THE PERIOD
OF RECORD

CHARACTERISTICS

MONTH	MAY	JUNE	JULY	AUG	SEPT
NUMBER OF OCCURRENCES	12	10	17	16	11
FREQUENCIES OF OCCURRENCES	2	2	3	3	2
MAP TYPE MOST	15/ 25	15/ 40	15/ 41	15/ 25	15/ 45
FREQUENTLY	1/ 17	35/ 20	4/ 24	2/ 19	1/ 9
FOLLOWING	11/ 17	1/ 10	1/ 18	1/ 13	4/ 9
(MAP TYPE/	U/ 17	4/ 10	2/ 12	4/ 13	11/ 9
FREQUENCY)	2/ 8	14/ 10	35/ 6	11/ 6	14/ 9
MOST FREQUENT	1/ 78	1/ 50	1/ 50	1/ 67	1/ 50
DURATION (NUMBER	2/ 11	2/ 33	2/ 30	2/ 33	3/ 33
OF 12HR PERIODS/	3/ 11	3/ 17	3/ 20		2/ 17
FREQUENCY)					

****
*   500 MB.   *
* MAP TYPE 16 *
****



****
PERIOD OF RECORD
1963-1971
****
THIS TYPE
OCCURRED 51 TIMES
DURING THE PERIOD
OF RECORD

CHARACTERISTICS

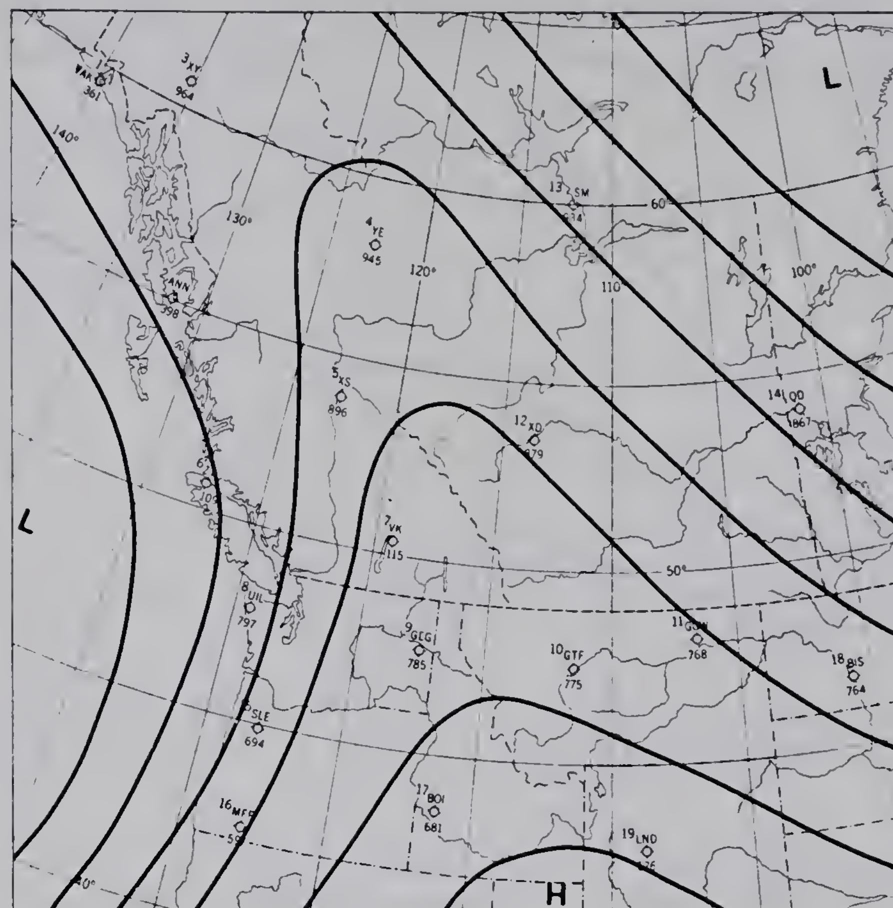
MONTH	MAY	JUNE	JULY	AUG	SEPT
NUMBER OF OCCURRENCES	26	8	0	2	15
FREQUENCIES OF OCCURRENCES	5	1	0	0	3
MAP TYPE MOST	16/ 64	16/ 38		2/ 50	16/ 40
FREQUENTLY	2/ 16	2/ 25		11/ 50	2/ 27
FOLLOWING	8/ 12	8/ 25			11/ 13
(MAP TYPE/	25/ 8	25/ 13			25/ 13
FREQUENCY)					8/ 7
MOST FREQUENT	2/ 50	2/ 60		1/100	1/ 56
DURATION (NUMBER	1/ 20	1/ 40			2/ 22
OF 12HR PERIODS/	3/ 10				3/ 22
FREQUENCY)	4/ 10				

****
*   500 MB.   *
* MAP TYPE 17 *
****

****
PERIOD OF RECORD
1963-1971
****
THIS TYPE
OCCURRED 24 TIMES
DURING THE PERIOD
OF RECORD

CHARACTERISTICS

MONTH	MAY	JUNE	JULY	AUG	SEPT
NUMBER OF OCCURRENCES	4	4	2	0	14
FREQUENCIES OF OCCURRENCES	1	1	0	0	3
MAP TYPE MOST	17/ 50	17/ 50	4/ 50		17/ 43
FREQUENTLY	28/ 25	23/ 25	17/ 50		32/ 29
FOLLOWING	U/ 25	U/ 25			4/ 14
(MAP TYPE/					6/ 7
FREQUENCY)					U/ 7
MOST FREQUENT	1/ 50	1/ 50	2/100		1/ 63
DURATION (NUMBER	3/ 50	3/ 50			2/ 13
OF 12HR PERIODS/					3/ 13
FREQUENCY)					4/ 13



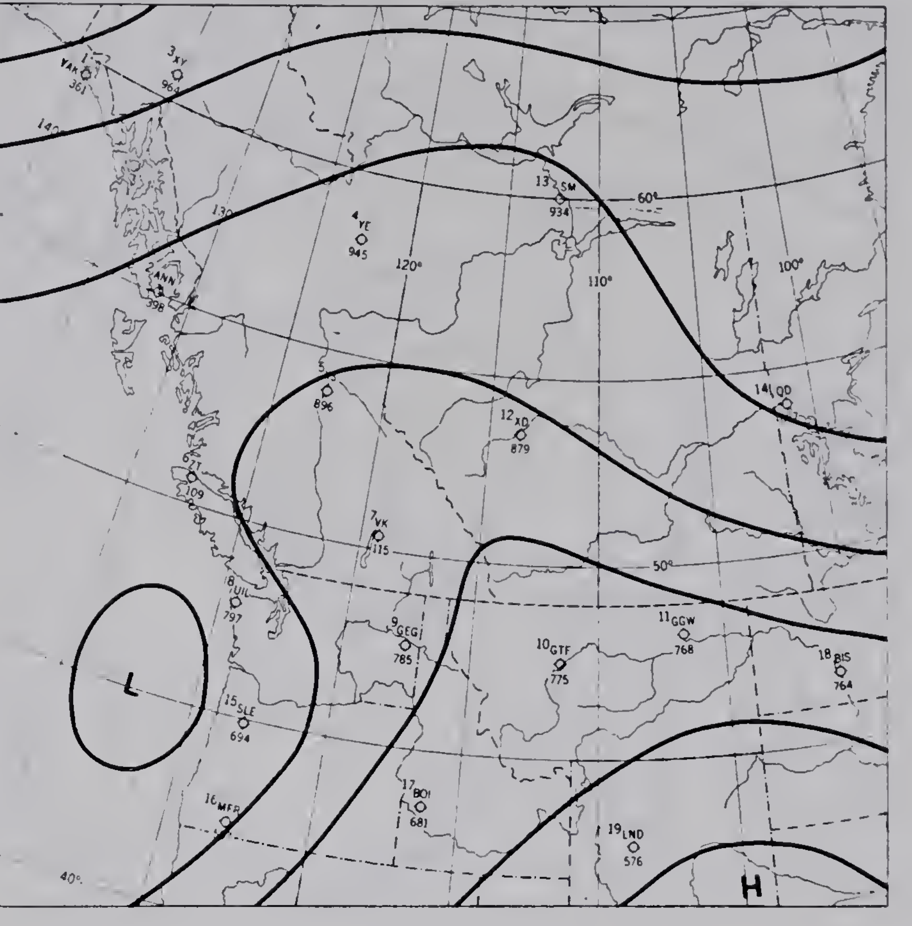
****
*   500 MB.   *
* MAP TYPE 18 *
****

****
PERIOD OF RECORD
1963-1971
****
THIS TYPE
OCCURRED 35 TIMES
DURING THE PERIOD
OF RECORD

CHARACTERISTICS

MONTH	MAY	JUNE	JULY	AUG	SEPT
NUMBER OF OCCURRENCES	4	6	5	17	3
FREQUENCIES OF OCCURRENCES	1	1	1	3	1
MAP TYPE MOST FREQUENTLY FOLLOWING (MAP TYPE/ FREQUENCY)	3/ 50 18/ 50	18/ 33 26/ 33 U/ 33	1/ 20 2/ 20 3/ 20 19/ 20 35/ 20	18/ 59 1/ 12 3/ 12 4/ 6 12/ 6	2/ 33 18/ 33 19/ 33
MOST FREQUENT DURATION (NUMBER OF 12HR PERIODS/ FREQUENCY)	2/100	1/ 50 2/ 50	1/100	1/ 43 2/ 29 5/ 29	1/ 50 2/ 50

****
*   500 MB.   *
* MAP TYPE 19 *
****



****
PERIOD OF RECORD
1963-1971
****
THIS TYPE
OCCURRED 55 TIMES
DURING THE PERIOD
OF RECORD

CHARACTERISTICS

MONTH	MAY	JUNE	JULY	AUG	SEPT
NUMBER OF OCCURRENCES	8	4	15	19	9
FREQUENCIES OF OCCURRENCES	1	1	3	3	2
MAP TYPE MOST	3/ 25	9/ 25	19/ 47	19/ 61	2/ 33
FREQUENTLY	19/ 25	19/ 25	1/ 20	1/ 6	3/ 22
FOLLOWING	21/ 25	21/ 25	3/ 20	2/ 6	19/ 22
(MAP TYPE/	31/ 13	31/ 25	5/ 7	3/ 6	5/ 11
FREQUENCY)	U/ 13		15/ 7	5/ 6	18/ 11
MOST FREQUENT	1/ 83	1/ 67	1/ 50	1/ 50	1/ 71
DURATION (NUMBER	3/ 17	2/ 33	3/ 38	3/ 25	2/ 29
OF 12HR PERIODS/			2/ 13	4/ 13	
FREQUENCY)				5/ 13	

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***************
*   500 MB.   *
* MAP TYPE 20 *
***************
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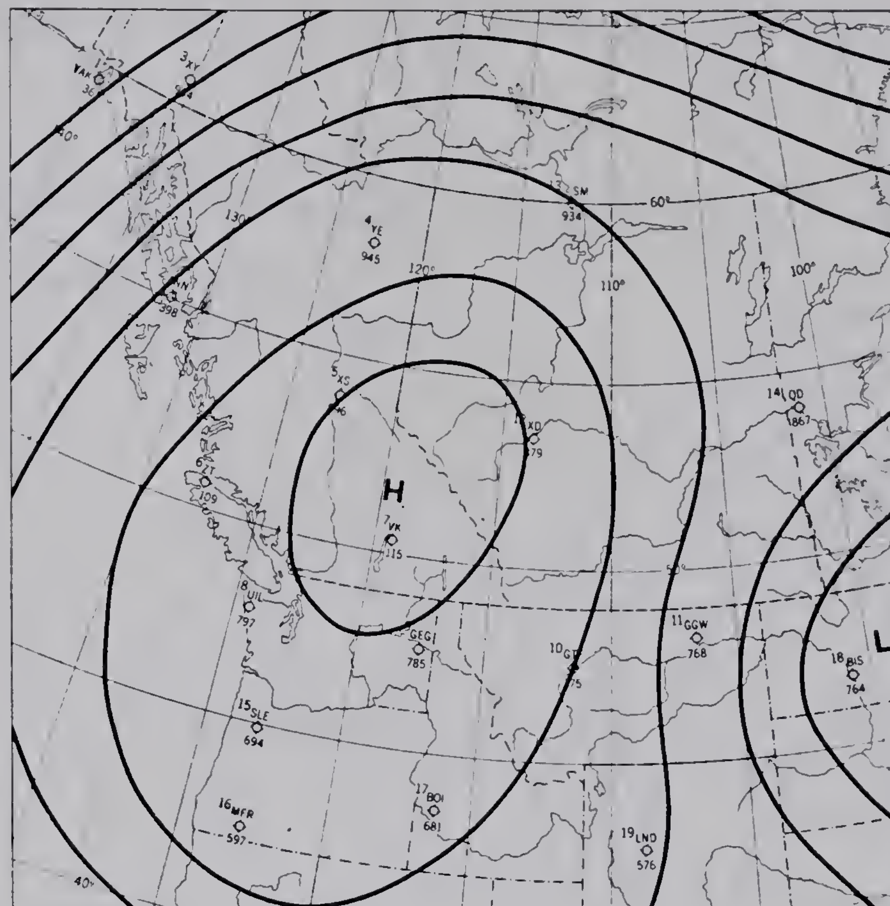


****
PERIOD OF RECORD
1963-1971
****
THIS TYPE
OCCURRED 18 TIMES
DURING THE PERIOD
OF RECORD

CHARACTERISTICS

MONTH	MAY	JUNE	JULY	AUG	SEPT
NUMBER OF OCCURRENCES	3	2	0	3	10
FREQUENCIES OF OCCURRENCES	1	0	0	1	2
MAP TYPE MOST FREQUENTLY FOLLOWING (MAP TYPE/ FREQUENCY)	11/ 33 20/ 33 U/ 33	2/ 50 20/ 50		U/ 67 20/ 33	20/ 80 16/ 10 U/ 10
MOST FREQUENT DURATION (NUMBER OF 12HR PERIODS/ FREQUENCY)	1/ 50 2/ 50	2/100		1/ 50 2/ 50	1/ 50 9/ 50

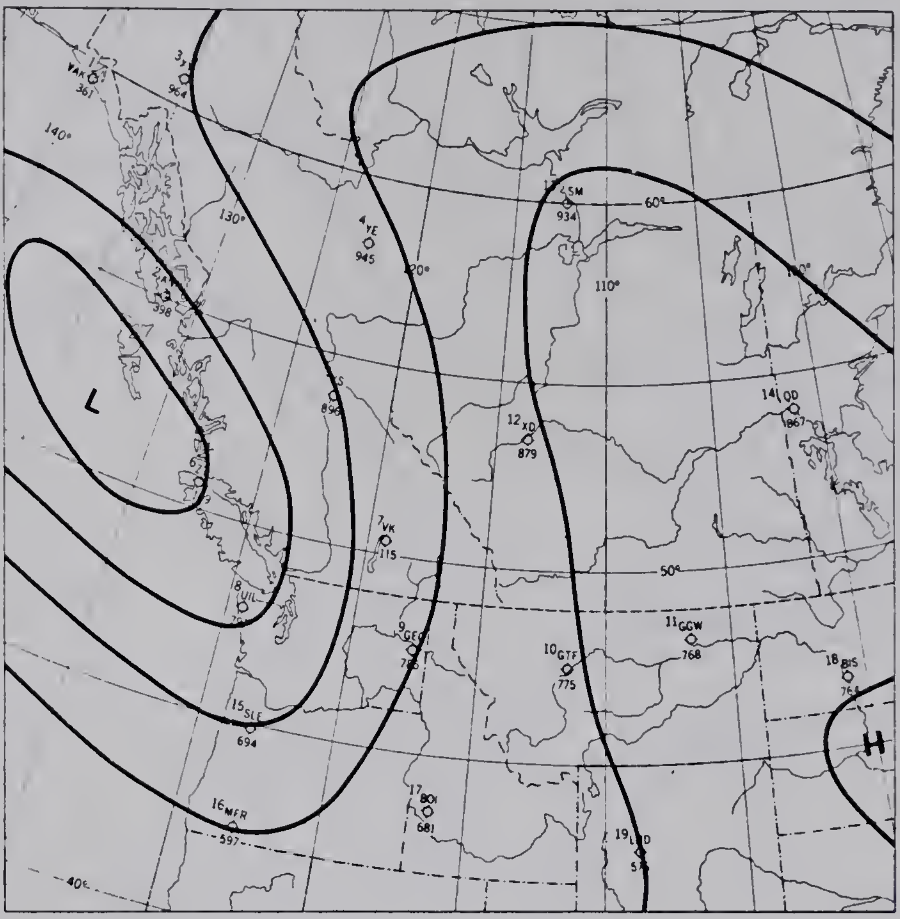
****
*   500 MB.   *
* MAP TYPE 21 *
****

****
PERIOD OF RECORD
1963-1971
****
THIS TYPE
OCCURRED 27 TIMES
DURING THE PERIOD
OF RECORD

CHARACTERISTICS

MONTH	MAY	JUNE	JULY	AUG	SEPT
NUMBER OF OCCURRENCES	4	4	7	5	7
FREQUENCIES OF OCCURRENCES	1	1	1	1	1
MAP TYPE MOST FREQUENTLY FOLLOWING (MAP TYPE/ FREQUENCY)	5/ 50 9/ 25 21/ 25	U/ 50 5/ 25 13/ 25	21/ 57 30/ 29 15/ 14	21/ 60 5/ 20 25/ 20	25/ 29 1/ 14 2/ 14 16/ 14 21/ 14
MOST FREQUENT DURATION (NUMBER OF 12HR PERIODS/ FREQUENCY)	1/ 67 2/ 33	1/100	2/ 67 3/ 33	2/ 50 3/ 50	1/ 83 2/ 17

****
*   500 MB.   *
* MAP TYPE 22 *
****

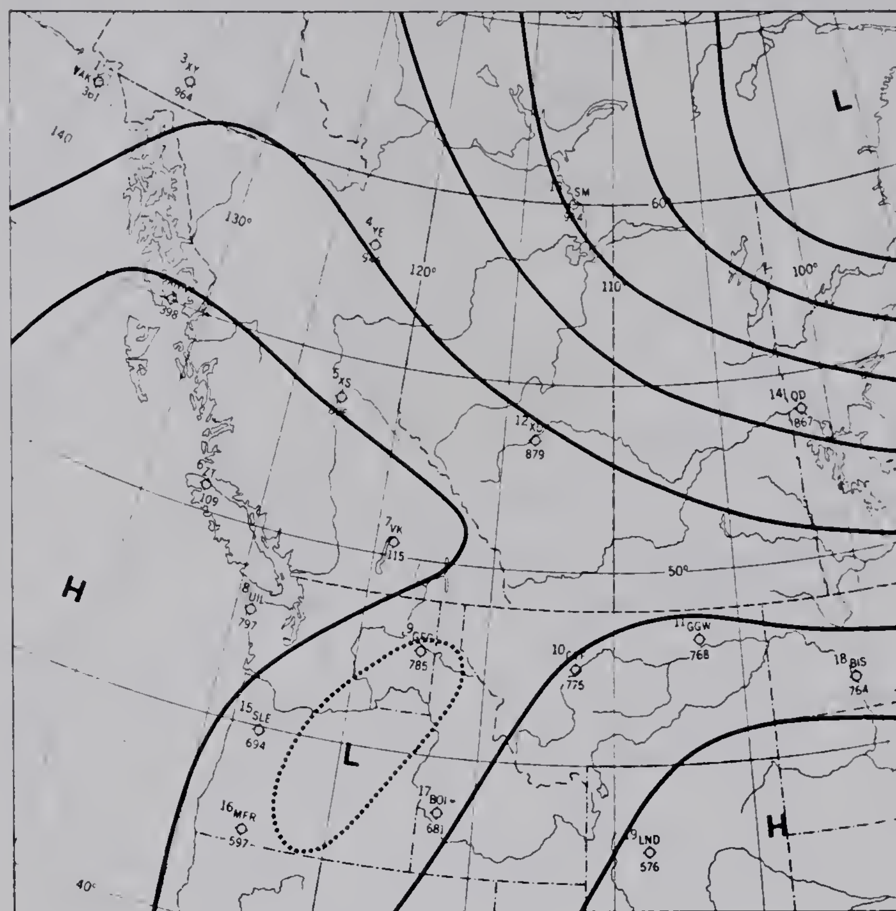


****
PERIOD OF RECORD
1963-1971
****
THIS TYPE
OCCURRED 26 TIMES
DURING THE PERIOD
OF RECORD

CHARACTERISTICS

MONTH	MAY	JUNE	JULY	AUG	SEPT
NUMBER OF OCCURRENCES	15	2	7	2	0
FREQUENCIES OF OCCURRENCES	3	0	1	0	0
MAP TYPE MOST FREQUENTLY FOLLOWING (MAP TYPE/ FREQUENCY)	22/ 53 U/ 27 3/ 7 5/ 7 9/ 7	5/ 50 U/ 50	22/ 43 3/ 29 9/ 14 U/ 14	22/100	
MOST FREQUENT DURATION (NUMBER OF 12HR PERIODS/ FREQUENCY)	1/ 43 3/ 29 2/ 14 4/ 14	1/100	1/ 50 2/ 25 3/ 25	2/100	

****
*   500 MB.   *
* MAP TYPE 23 *
****



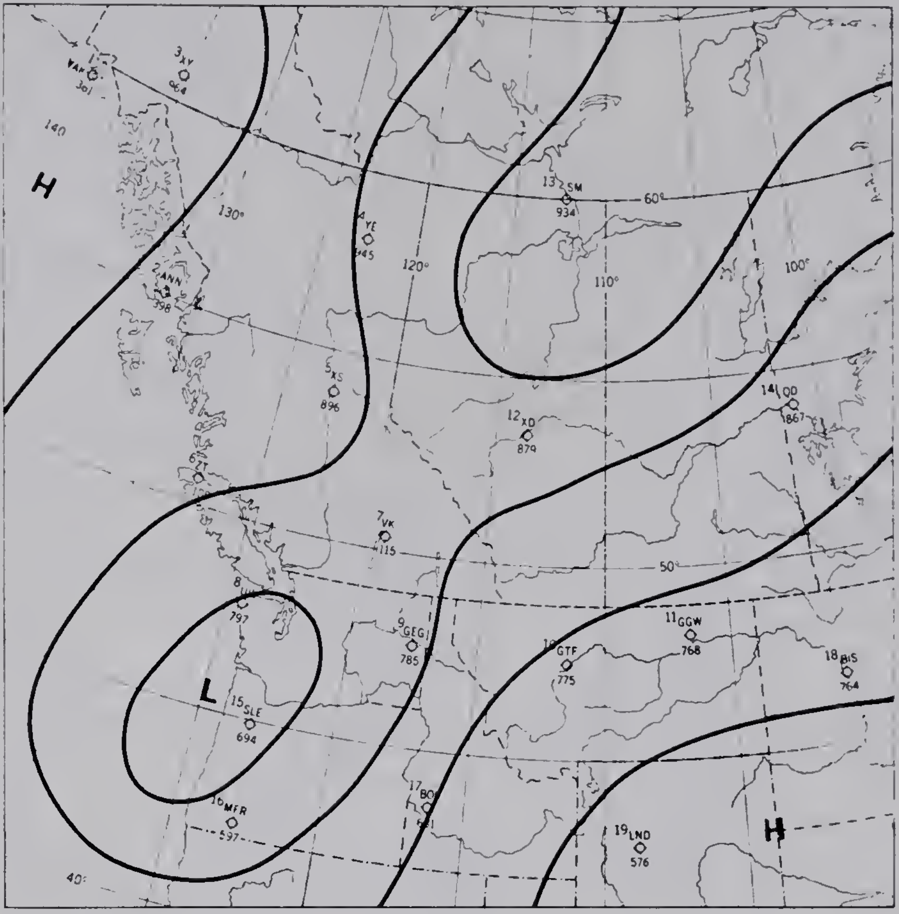
****
PERIOD OF RECORD
1963-1971
****
THIS TYPE
OCCURRED 17 TIMES
DURING THE PERIOD
OF RECORD

CHARACTERISTICS

MONTH	MAY	JUNE	JULY	AUG	SEPT
NUMBER OF OCCURRENCES	3	3	2	6	3
FREQUENCIES OF OCCURRENCES	1	1	0	1	1
MAP TYPE MOST FREQUENTLY FOLLOWING (MAP TYPE/ FREQUENCY)	2/ 33 16/ 33 28/ 33	23/ 67 2/ 33	2/100	2/ 33 4/ 17 23/ 17 28/ 17 U/ 17	23/ 67 17/ 33
MOST FREQUENT DURATION (NUMBER OF 12HR PERIODS/ FREQUENCY)	1/100	3/100	1/100	1/ 80 2/ 20	3/100

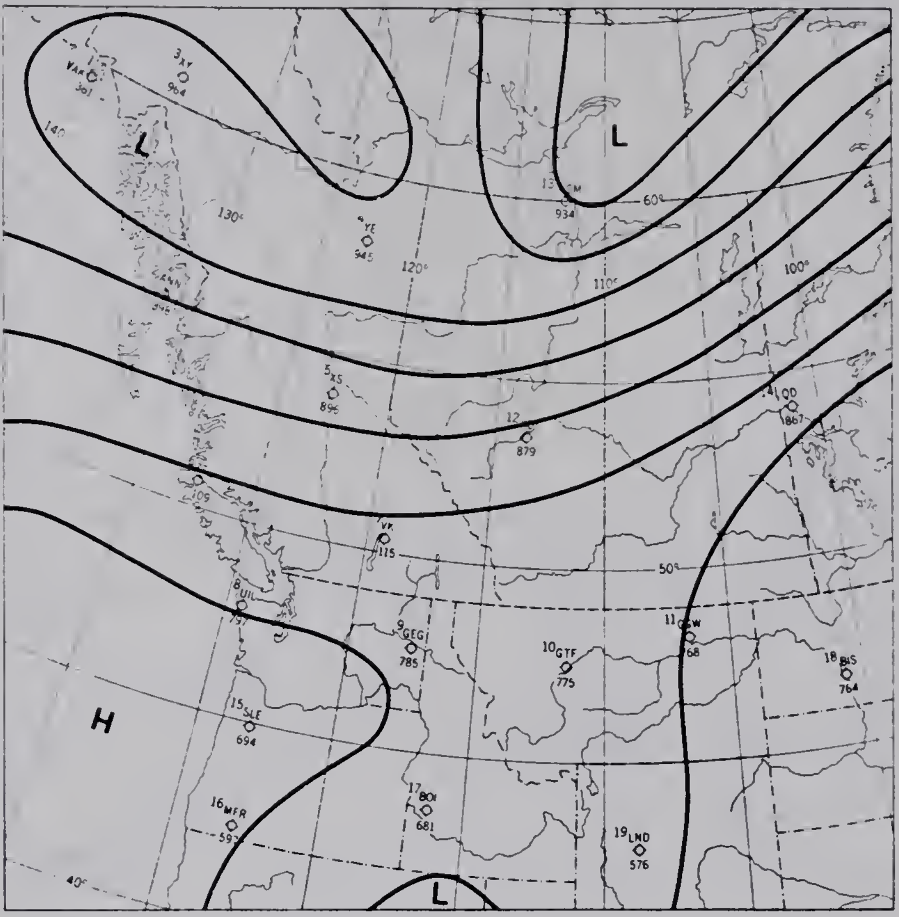
```
***************
*   500 MB.   *
* MAP TYPE 24 *
***************
```

****
PERIOD OF RECORD
1963-1971
****
THIS TYPE
OCCURRED 15 TIMES
DURING THE PERIOD
OF RECORD



CHARACTERISTICS

MONTH	MAY	JUNE	JULY	AUG	SEPT
NUMBER OF OCCURRENCES	1	2	4	7	1
FREQUENCIES OF OCCURRENCES	0	0	1	1	0
MAP TYPE MOST FREQUENTLY FOLLOWING (MAP TYPE/ FREQUENCY)	U/100	24/ 50 U/ 50	7/ 25 9/ 25 24/ 25 27/ 25	24/ 83 27/ 17	U/100
MOST FREQUENT DURATION (NUMBER OF 12HR PERIODS/ FREQUENCY)	1/100	2/100	1/ 67 2/ 33	1/ 50 6/ 50	1/100

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***************
*   500 MB.   *
* MAP TYPE 25 *
***************
```

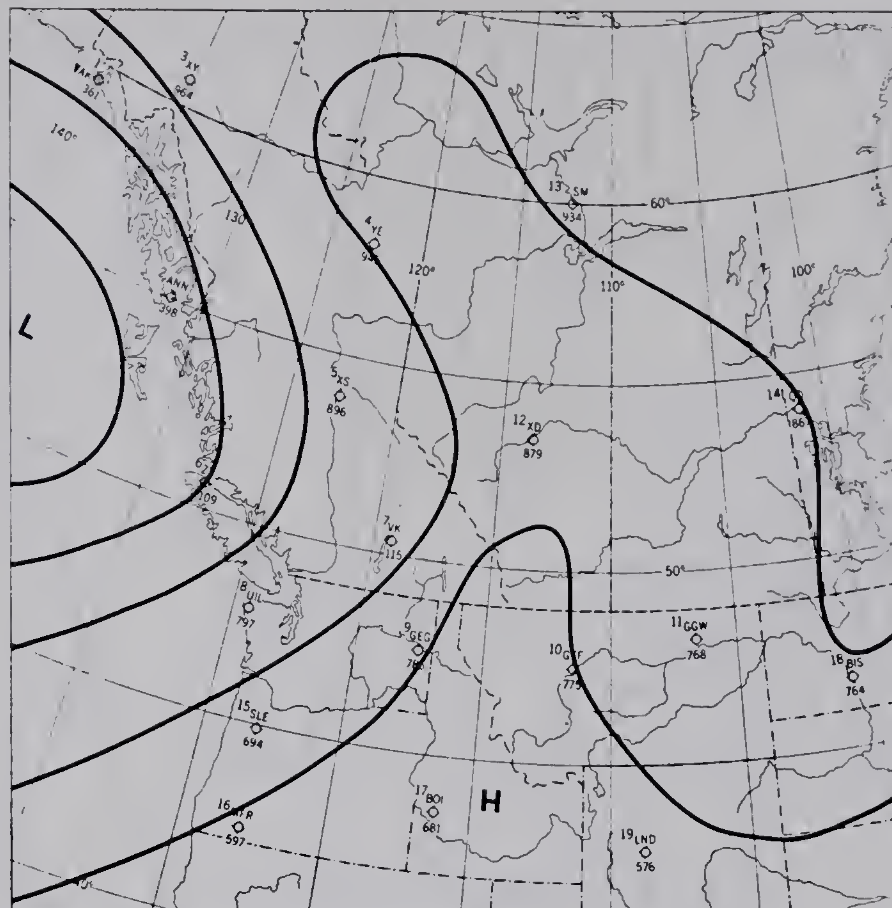
****
PERIOD OF RECORD
1963-1971
****
THIS TYPE
OCCURRED 64 TIMES
DURING THE PERIOD
OF RECORD

CHARACTERISTICS

MONTH	MAY	JUNE	JULY	AUG	SEPT
NUMBER OF OCCURRENCES	14	8	9	11	22
FREQUENCIES OF OCCURRENCES	3	1	2	2	4
MAP TYPE MOST	2/ 36	U/ 50	1/ 44	1/ 30	25/ 45
FREQUENTLY	25/ 29	25/ 25	25/ 33	8/ 20	2/ 25
FOLLOWING	1/ 14	1/ 13	2/ 11	25/ 20	1/ 20
(MAP TYPE/	8/ 7	4/ 13	19/ 11	4/ 10	8/ 5
FREQUENCY)	33/ 7			19/ 10	19/ 5
MOST FREQUENT	1/ 70	1/ 83	1/ 67	1/ 78	1/ 46
DURATION (NUMBER	2/ 20	3/ 17	2/ 17	2/ 22	2/ 38
OF 12HR PERIODS/	3/ 10		3/ 17		3/ 15
FREQUENCY)					

****
*   500 MB.   *
* MAP TYPE 26 *
****

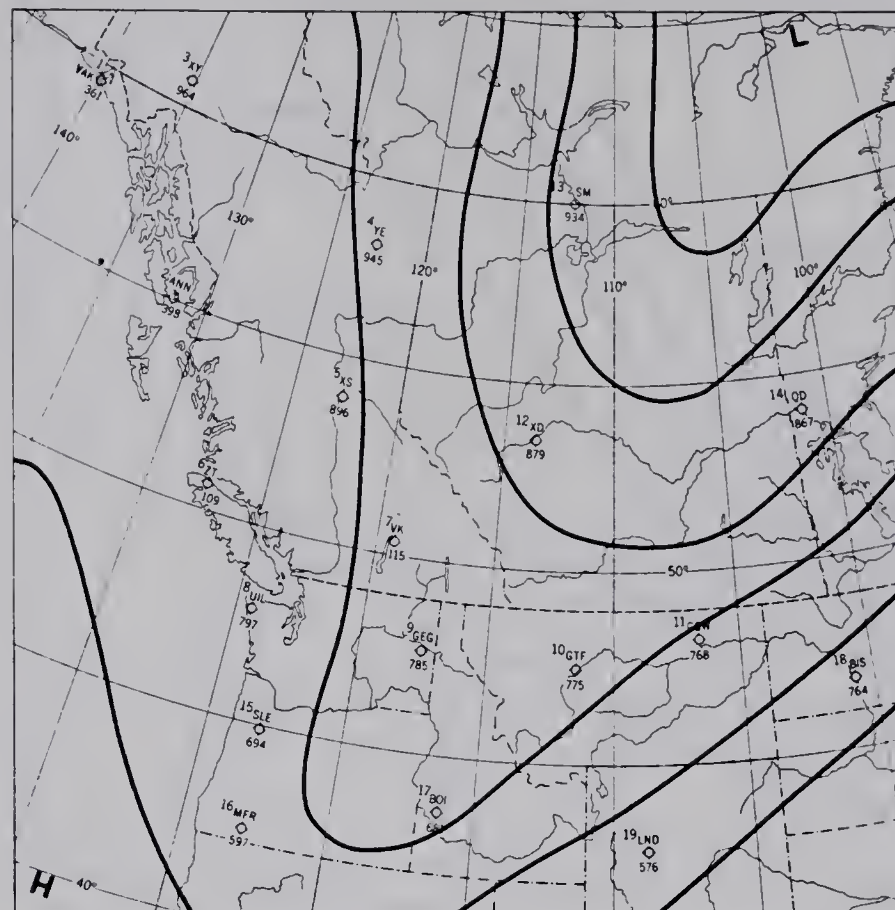
****
PERIOD OF RECORD
1963-1971
****
THIS TYPE
OCCURRED 20 TIMES
DURING THE PERIOD
OF RECORD



CHARACTERISTICS

MONTH	MAY	JUNE	JULY	AUG	SEPT
NUMBER OF OCCURRENCES	4	10	1	5	0
FREQUENCIES OF OCCURRENCES	1	2	0	1	0
MAP TYPE MOST FREQUENTLY FOLLOWING (MAP TYPE/ FREQUENCY)	U/ 50 1/ 25 26/ 25	26/ 40 1/ 20 3/ 20 18/ 10 U/ 10	1/100	3/ 40 26/ 40 8/ 20	
MOST FREQUENT DURATION (NUMBER OF 12HR PERIODS/ FREQUENCY)	1/ 67 2/ 33	1/ 67 2/ 17 4/ 17	1/100	2/ 67 1/ 33	

****
*   500 MB.   *
* MAP TYPE 27 *
****

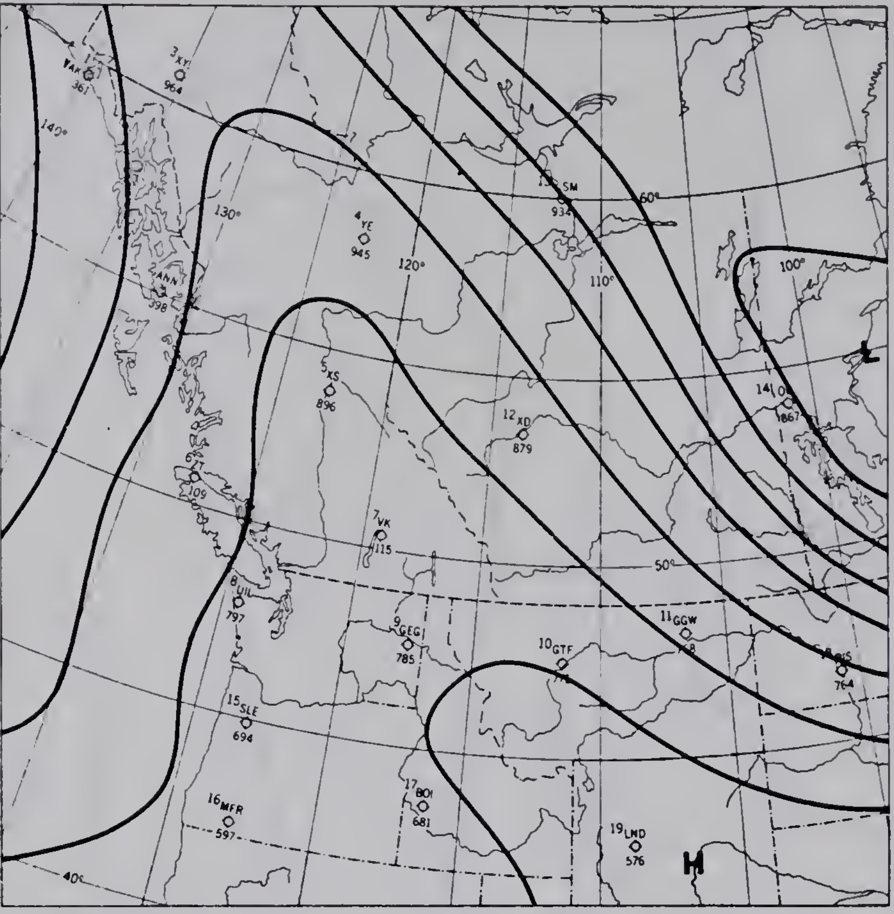


****
PERIOD OF RECORD
1963-1971
****
THIS TYPE
OCCURRED 17 TIMES
DURING THE PERIOD
OF RECORD

CHARACTERISTICS

MONTH	MAY	JUNE	JULY	AUG	SEPT
NUMBER OF OCCURRENCES	3	4	5	4	1
FREQUENCIES OF OCCURRENCES	1	1	1	1	0
MAP TYPE MOST FREQUENTLY FOLLOWING (MAP TYPE/ FREQUENCY)	23/ 67 4/ 33	27/ 75 33/ 25	27/ 40 4/ 20 24/ 20 U/ 20	4/ 25 15/ 25 27/ 25 U/ 25	17/100
MOST FREQUENT DURATION (NUMBER OF 12HR PERIODS/ FREQUENCY)	1/100	4/100	2/ 67 1/ 33	1/ 67 2/ 33	1/100

****
*   500 MB.   *
* MAP TYPE 28 *
****

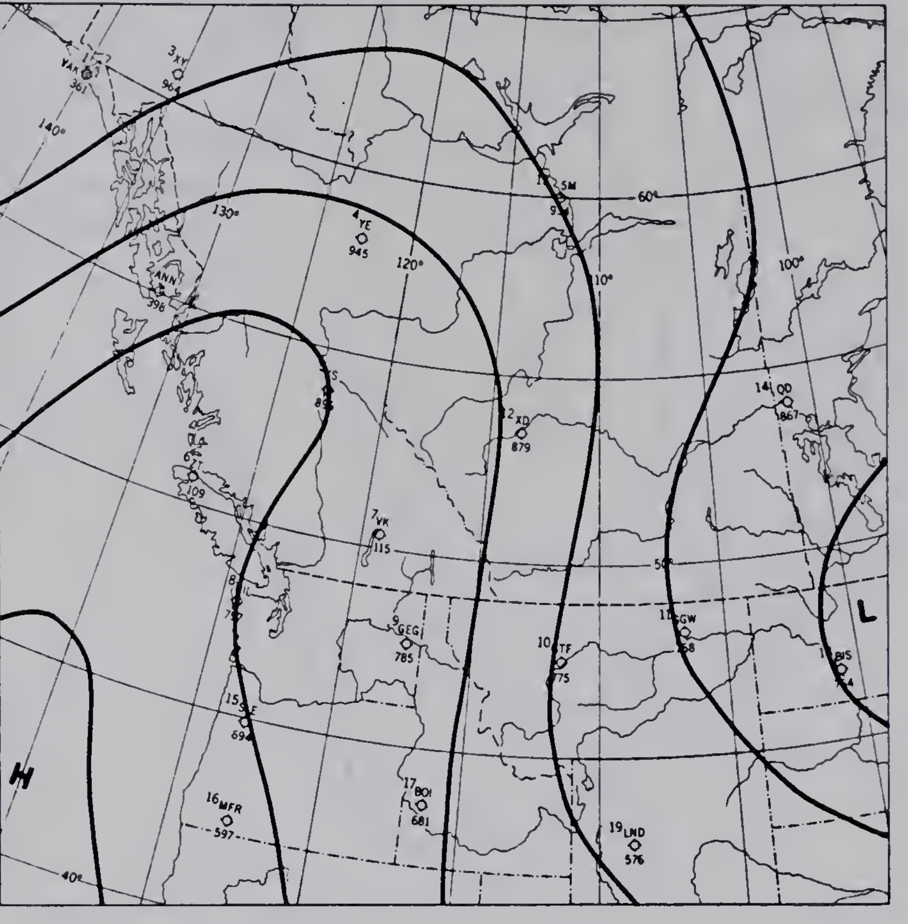


****
PERIOD OF RECORD
1963-1971
****
THIS TYPE
OCCURRED 36 TIMES
DURING THE PERIOD
OF RECORD

CHARACTERISTICS

MONTH	MAY	JUNE	JULY	AUG	SEPT
NUMBER OF OCCURRENCES	6	7	5	14	4
FREQUENCIES OF OCCURRENCES	1	1	1	3	1
MAP TYPE MOST FREQUENTLY FOLLOWING (MAP TYPE/ FREQUENCY)	28/ 33 2/ 17 6/ 17 18/ 17 23/ 17	28/ 43 4/ 29 2/ 14 U/ 14	2/ 50 1/ 25 18/ 25	28/ 36 2/ 21 U/ 14 4/ 7 8/ 7	1/ 25 2/ 25 8/ 25 28/ 25
MOST FREQUENT DURATION (NUMBER OF 12HR PERIODS/ FREQUENCY)	1/ 75 3/ 25	1/ 50 2/ 25 3/ 25	1/100	1/ 56 2/ 33 3/ 11	1/ 67 2/ 33

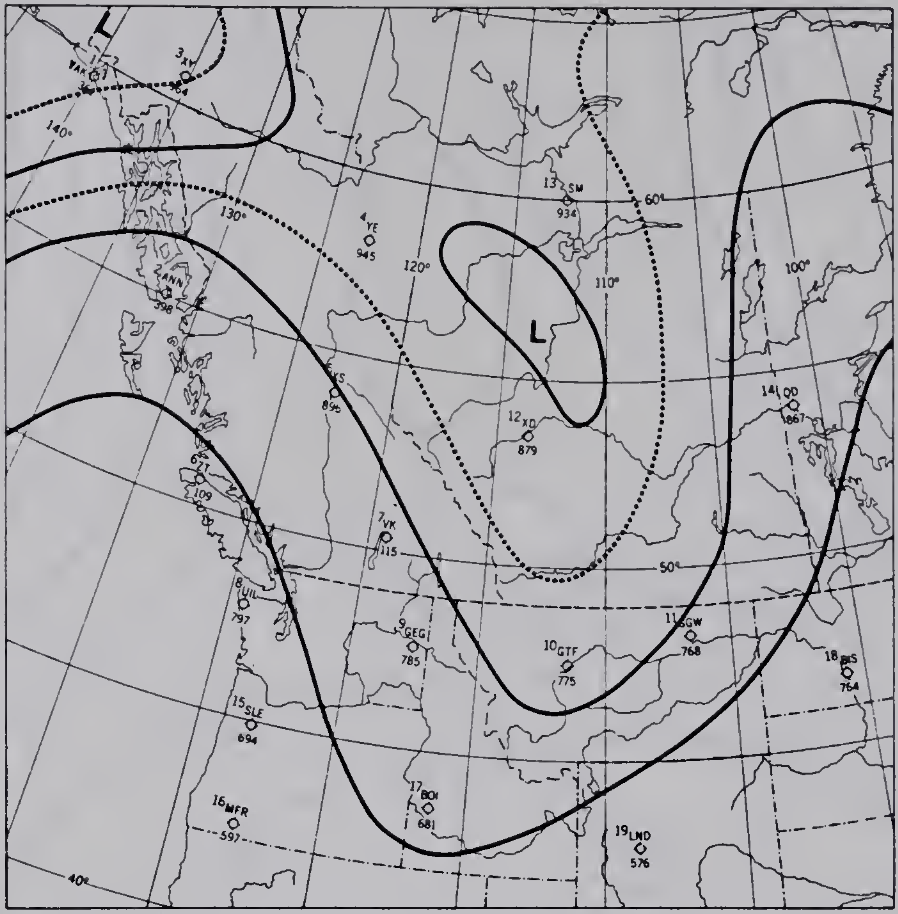
****
*   500 MB.   *
* MAP TYPE 29 *
****



****
PERIOD OF RECORD
1963-1971
****
THIS TYPE
OCCURRED 13 TIMES
DURING THE PERIOD
OF RECORD

CHARACTERISTICS

MONTH	MAY	JUNE	JULY	AUG	SEPT
NUMBER OF OCCURRENCES	6	0	3	0	4
FREQUENCIES OF OCCURRENCES	1	0	1	0	1
MAP TYPE MOST FREQUENTLY FOLLOWING (MAP TYPE/ FREQUENCY)	29/ 50 6/ 17 20/ 17 U/ 17		6/ 67 29/ 33		29/ 75 U/ 25
MOST FREQUENT DURATION (NUMBER OF 12HR PERIODS/ FREQUENCY)	1/ 67 4/ 33		1/ 50 2/ 50		4/100

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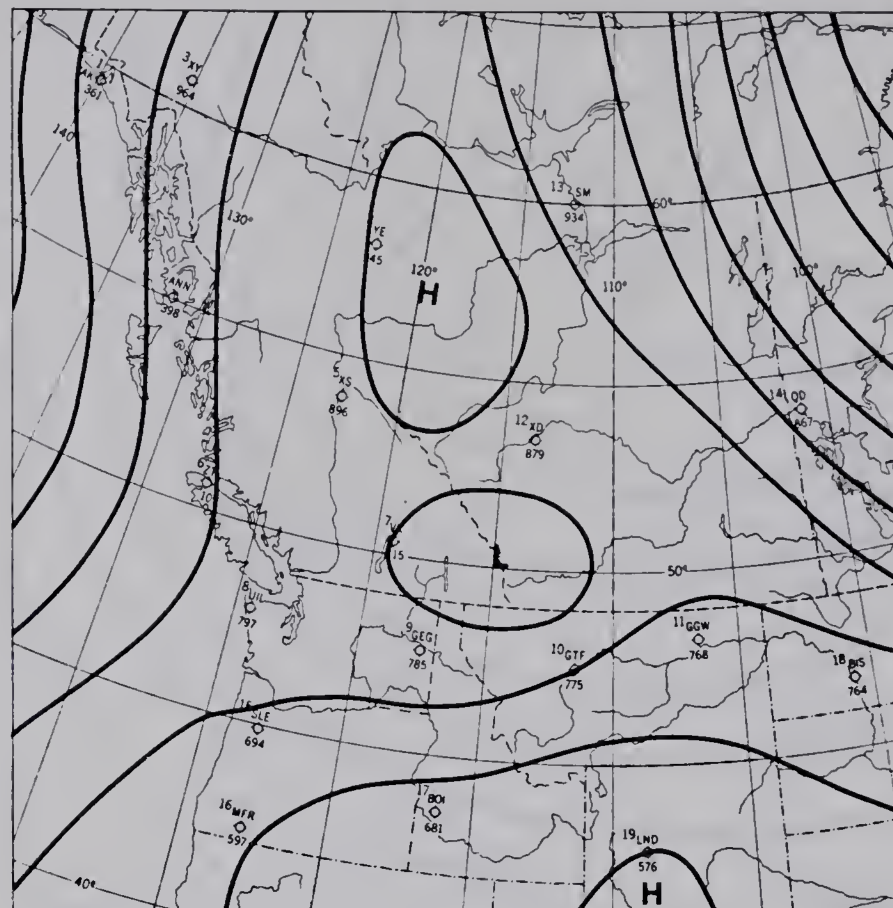
***************
*   500 MB.   *
* MAP TYPE 30 *
***************
```

****
PERIOD OF RECORD
1963-1971
****
THIS TYPE
OCCURRED 18 TIMES
DURING THE PERIOD
OF RECORD

CHARACTERISTICS

MONTH	MAY	JUNE	JULY	AUG	SEPT
NUMBER OF OCCURRENCES	3	5	8	1	1
FREQUENCIES OF OCCURRENCES	1	1	1	0	0
MAP TYPE MOST FREQUENTLY FOLLOWING (MAP TYPE/ FREQUENCY)	2/ 67 U/ 33	30/ 40 16/ 20 25/ 20 U/ 20	2/ 50 30/ 38 5/ 13	2/100	16/100
MOST FREQUENT DURATION (NUMBER OF 12HR PERIODS/ FREQUENCY)	1/100	2/ 67 1/ 33	1/ 80 4/ 20	1/100	1/100

```
***************
*   500 MB.   *
* MAP TYPE 31 *
***************
```



****

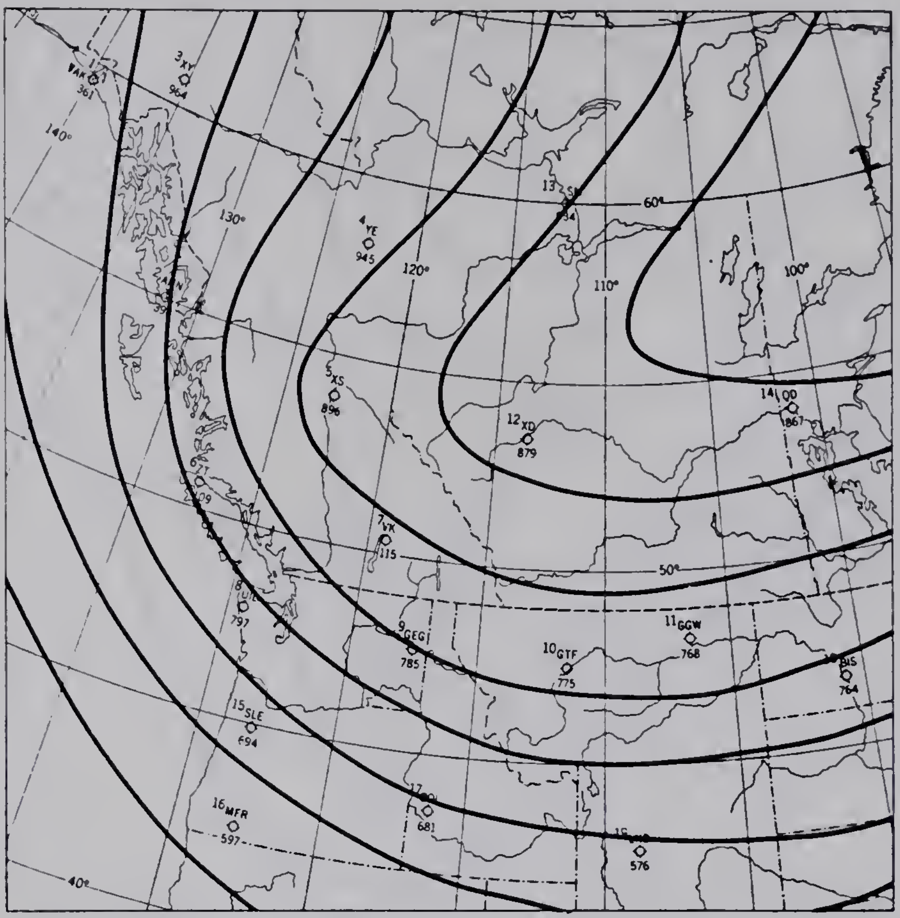
PERIOD OF RECORD
1963-1971

****

THIS TYPE
OCCURRED 13 TIMES
DURING THE PERIOD
OF RECORD

CHARACTERISTICS

MONTH	MAY	JUNE	JULY	AUG	SEPT
NUMBER OF OCCURRENCES	4	4	3	2	0
FREQUENCIES OF OCCURRENCES	1	1	1	0	0
MAP TYPE MOST FREQUENTLY FOLLOWING (MAP TYPE/ FREQUENCY)	31/ 50 21/ 25 U/ 25	19/ 50 1/ 25 31/ 25	31/ 67 11/ 33	8/100	
MOST FREQUENT DURATION (NUMBER OF 12HR PERIODS/ FREQUENCY)	2/100	1/ 67 2/ 33	3/100	1/100	

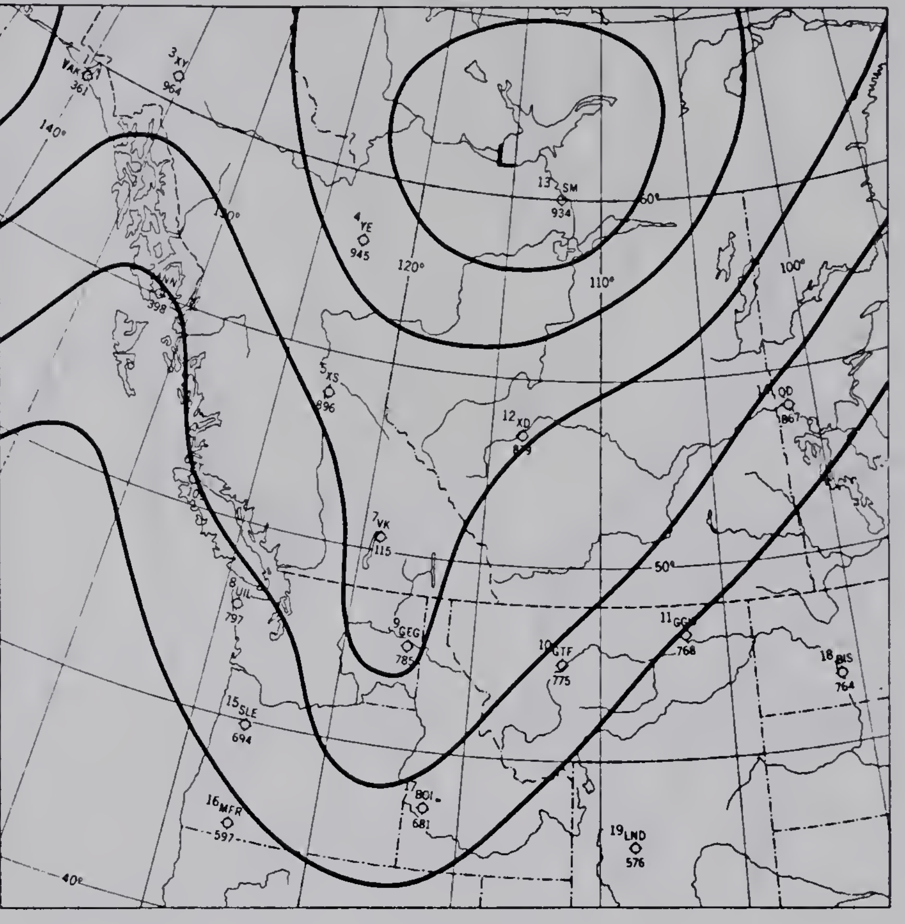


****
*   500 MB.   *
* MAP TYPE 32 *
****

****
PERIOD OF RECORD
1963-1971
****
THIS TYPE
OCCURRED 15 TIMES
DURING THE PERIOD
OF RECORD

CHARACTERISTICS

MONTH	MAY	JUNE	JULY	AUG	SEPT
NUMBER OF OCCURRENCES	0	0	0	0	15
FREQUENCIES OF OCCURRENCES	0	0	0	0	3
MAP TYPE MOST FREQUENTLY FOLLOWING (MAP TYPE/ FREQUENCY)					32/ 33 17/ 27 U/ 20 10/ 13 34/ 7
MOST FREQUENT DURATION (NUMBER OF 12HR PERIODS/ FREQUENCY)					1/ 60 2/ 30 3/ 10



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***************
*   500 MB.   *
* MAP TYPE 33 *
***************
```
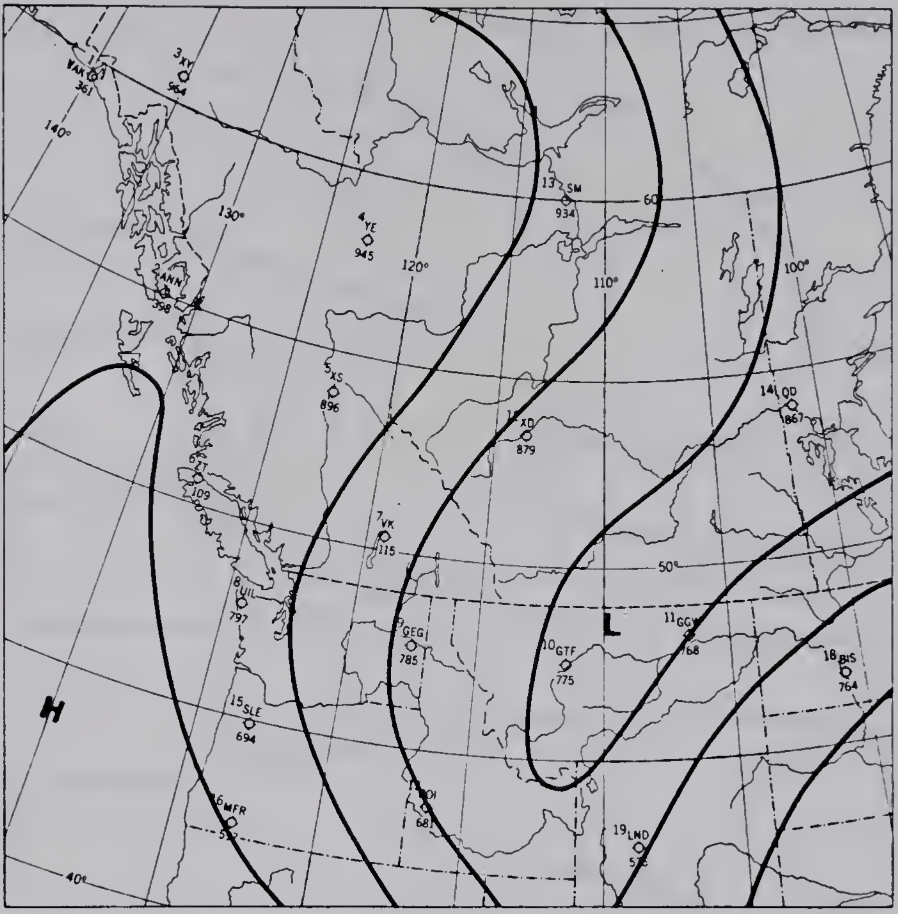

****
PERIOD OF RECORD
1963-1971
****
THIS TYPE
OCCURRED 19 TIMES
DURING THE PERIOD
OF RECORD

CHARACTERISTICS

MONTH	MAY	JUNE	JULY	AUG	SEPT
NUMBER OF OCCURRENCES	3	4	5	4	3
FREQUENCIES OF OCCURRENCES	1	1	1	1	1
MAP TYPE MOST FREQUENTLY FOLLOWING (MAP TYPE/ FREQUENCY)	1/ 33 4/ 33 30/ 33	1/ 25 17/ 25 25/ 25 30/ 25	33/ 40 2/ 20 4/ 20 25/ 20	1/ 50 33/ 25 U/ 25	2/ 33 25/ 33 33/ 33
MOST FREQUENT DURATION (NUMBER OF 12HR PERIODS/ FREQUENCY)	1/100	1/100	2/ 67 1/ 33	1/ 67 2/ 33	1/ 50 2/ 50

****
*   500 MB.   *
* MAP TYPE 34 *
****

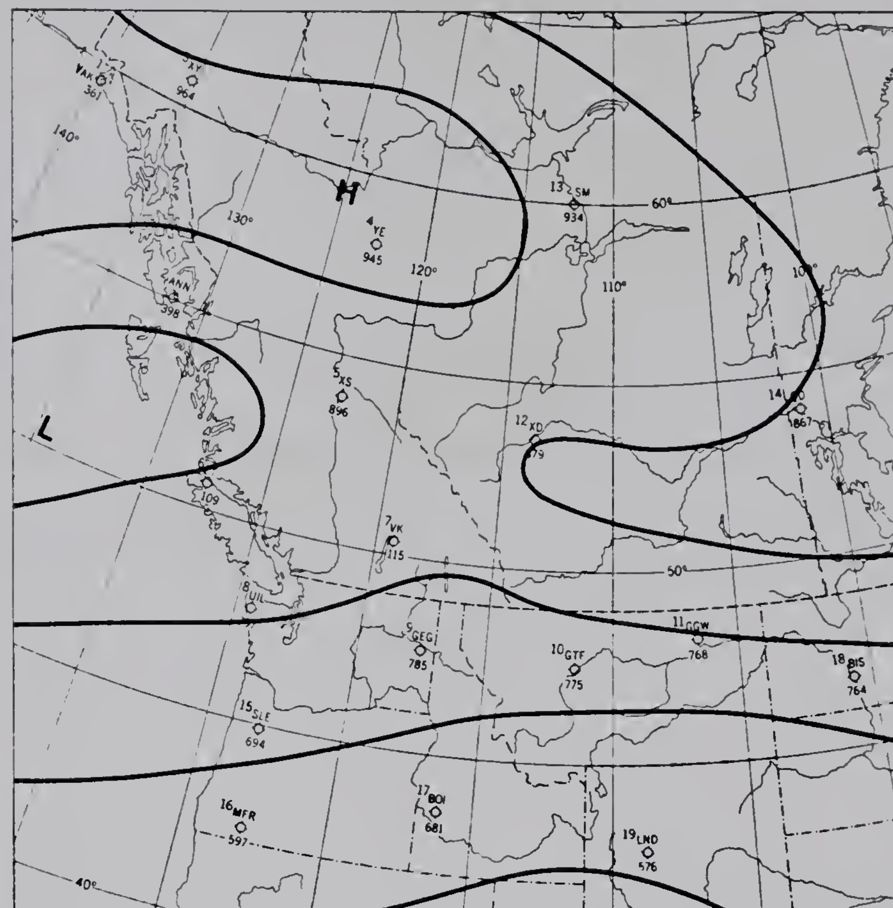


****
PERIOD OF RECORD
1963-1971
****
THIS TYPE
OCCURRED 7 TIMES
DURING THE PERIOD
OF RECORD

CHARACTERISTICS

MONTH	MAY	JUNE	JULY	AUG	SEPT
NUMBER OF OCCURRENCES	0	2	0	0	5
FREQUENCIES OF OCCURRENCES	0	0	0	0	1
MAP TYPE MOST FREQUENTLY FOLLOWING (MAP TYPE/ FREQUENCY)		34/100			34/ 60 10/ 20 U/ 20
MOST FREQUENT DURATION (NUMBER OF 12HR PERIODS/ FREQUENCY)		2/100			2/ 50 3/ 50

```
***************
*    500 MB.    *
* MAP TYPE 35 *
***************
```



****
PERIOD OF RECORD
1963-1971
****
THIS TYPE
OCCURRED 18 TIMES
DURING THE PERIOD
OF RECORD

CHARACTERISTICS

MONTH	MAY	JUNE	JULY	AUG	SEPT
NUMBER OF OCCURRENCES	3	5	6	4	0
FREQUENCIES OF OCCURRENCES	1	1	1	1	0
MAP TYPE MOST FREQUENTLY FOLLOWING (MAP TYPE/ FREQUENCY)	12/ 67 35/ 33	11/ 40 12/ 20 35/ 20 U/ 20	12/ 50 7/ 17 35/ 17 U/ 17	35/ 75 12/ 25	
MOST FREQUENT DURATION (NUMBER OF 12HR PERIODS/ FREQUENCY)	1/ 50 2/ 50	1/ 75 2/ 25	1/ 80 2/ 20	4/100	

```
********************
*      500 MB.     *
* UNCORRELATED MAPS *
********************
```

****
PERIOD OF RECORD
1963-1971
****
322 MAPS WERE
UNCORRELATED
DURING THE PERIOD
OF RECORD

CHARACTERISTICS

MONTH	MAY	JUNE	JULY	AUG	SEPT
NUMBER OF OCCURRENCES	97	119	18	48	40
FREQUENCIES OF OCCURRENCES	17	22	3	9	7
MAP TYPE MOST FREQUENTLY FOLLOWING (MAP TYPE/ FREQUENCY)	U/ 67 14/ 5 16/ 4 6/ 2 8/ 2	U/ 66 1/ 3 6/ 3 10/ 3 13/ 3	U/ 44 2/ 6 4/ 6 7/ 6 8/ 6	U/ 55 14/ 6 2/ 4 3/ 4 4/ 4	U/ 54 16/ 8 32/ 8 14/ 5 20/ 5
MOST FREQUENT DURATION (NUMBER OF 12HR PERIODS/ FREQUENCY)	1/ 37 2/ 20 3/ 17 4/ 11	1/ 44 2/ 23 4/ 9 3/ 7	1/ 60 2/ 20 3/ 10 5/ 10	1/ 55 3/ 18 2/ 14 4/ 5	1/ 58 2/ 16 3/ 11 4/ 11

APPENDIX 5

SUMMER 500 MB. MAP TYPE PoPs

The twenty-four hour percent probabilities of precipitation ($\geq$ 0.01 inches) are listed for each 500 mb. map type. The number of cases used to calculate the probabilities are indicated for each map type.

The station locations are shown in Figure 5 (page 52).

500 MB. MAP TYPE	XJ	YE	CT	EG	XD	RM	VG	QF	YC	QL	XH	PC	BA	JA	ET	MM	ZH	ZU	PY	OJ	QU	PE	OD	NUMBER OF CASES
1	37	47	26	38	34	40	33	35	26	15	11	15	33	43	41	48	42	40	40	41	41	35	40	422
2	20	32	15	20	22	19	17	16	11	6	8	7	12	17	22	33	24	23	29	31	20	21	25	276
3	50	50	33	51	45	54	44	53	36	25	23	27	58	56	55	56	59	55	40	45	56	48	53	201
4	37	36	38	44	39	49	38	44	55	38	24	39	48	35	46	48	43	40	38	34	38	45	43	89
5	25	44	34	31	32	31	31	34	46	31	34	35	50	37	40	35	32	34	35	22	28	21	41	68
6	15	21	23	17	21	21	17	19	25	21	12	21	21	13	25	42	19	19	27	13	15	13	29	52
7	66	39	54	80	78	66	59	59	59	34	32	44	71	49	66	51	76	63	34	32	63	59	63	41
8	31	46	15	21	21	20	17	16	16	12	7	10	22	32	26	27	30	26	25	30	38	27	23	175
9	23	15	54	54	46	62	54	54	54	69	62	69	69	54	77	38	38	62	38	31	54	31	46	13
10	5	11	11	16	5	26	5	32	37	37	11	42	21	16	16	16	11	5	5	11	5	11	5	19
11	41	45	29	36	33	37	37	36	23	13	20	14	30	34	41	49	36	40	37	45	32	42	37	103
12	54	31	50	54	50	73	46	65	69	27	23	46	62	38	69	23	54	54	35	19	54	42	35	26
13	0	27	27	36	36	64	45	64	73	55	55	73	73	36	45	55	18	27	9	9	9	18	64	11
14	30	26	44	40	42	42	44	47	35	47	37	44	30	21	30	49	44	30	51	28	33	37	44	43
15	61	44	56	61	58	59	63	61	56	44	41	31	51	46	56	61	64	61	54	51	61	58	71	59
16	16	41	7	14	9	9	16	16	2	7	7	5	7	11	7	25	14	16	25	18	16	16	20	44
17	20	40	45	40	40	55	40	55	45	45	30	55	50	20	40	45	55	50	40	20	35	35	55	20
18	26	19	11	19	26	26	11	19	19	11	11	7	41	44	37	33	19	37	19	33	33	11	19	27

500 MB. MAP TYPE	XJ	YE	CT	EG	XD	RM	VG	QF	YC	QL	XH	PC	BA	JA	ET	MM	ZH	ZU	PY	OJ	QU	PE	OD	NUMBER OF CASES
19	24	30	31	26	26	43	24	33	30	30	26	28	41	43	44	22	26	33	15	20	33	19	20	54
20	0	0	0	8	0	8	8	8	0	0	8	0	0	0	0	8	0	0	0	0	0	8	0	12
21	44	31	63	50	44	81	69	88	75	56	50	63	75	38	75	50	19	31	50	25	38	31	63	16
22	61	56	22	61	56	61	28	39	50	28	33	44	78	61	89	39	78	78	22	33	78	61	50	18
23	27	27	7	27	20	33	20	20	13	13	13	13	20	7	13	33	27	13	20	13	13	33	13	15
24	36	18	55	64	64	82	45	73	73	82	82	55	82	55	73	55	64	64	36	18	64	18	45	11
25	19	37	15	23	22	26	18	22	18	13	8	16	17	23	30	35	35	29	47	29	19	17	28	93
26	58	55	21	24	18	33	12	15	9	9	9	15	33	42	42	42	45	39	15	39	52	48	21	33
27	25	25	38	50	38	75	13	38	75	63	38	38	63	50	50	50	63	50	50	25	38	25	38	8
28	18	24	11	13	13	20	13	16	18	13	5	11	13	7	20	20	16	24	18	16	15	18	29	55
29	0	0	30	20	10	10	0	40	20	30	40	20	10	10	0	50	20	0	20	10	10	0	20	10
30	40	27	60	33	40	53	53	53	47	47	47	27	33	40	40	33	40	53	33	33	27	27	67	15
31	43	0	43	57	57	57	43	86	71	57	43	43	71	29	43	14	43	29	14	14	29	14	43	7
32	27	45	82	64	55	82	45	82	55	64	45	73	73	27	73	36	45	45	55	18	36	27	45	11
33	24	24	62	57	43	57	52	62	48	52	52	33	48	33	48	57	43	43	52	24	24	48	43	21
34	25	50	50	25	25	75	25	50	25	100	75	100	50	50	25	25	75	75	25	25	25	0	50	4
35	53	27	53	67	73	60	47	47	53	27	20	40	60	47	87	40	53	80	33	40	53	60	27	15
U	36	31	37	35	35	48	27	45	47	53	40	58	52	42	45	21	25	33	19	19	33	23	23	159

APPENDIX 6

SUMMER SURFACE MAP TYPE PoPs

The twenty-four hour percent probabilities of precipitation ($\geq$ 0.01 inches) are listed for each surface map type. The number of cases used to calculate the probabilities are indicated for each map type.

The station locations are shown in Figure 5 (page 52).

SURFACE MAP TYPE	XJ	YE	CT	EG	XD	RM	VG	QF	YC	QL	XH	PC	BA	JA	ET	MM	ZH	ZU	PY	OJ	QU	PE	OD	NUMBER OF CASES
1	41	26	48	46	46	70	37	65	70	61	37	67	63	41	72	24	33	61	11	17	48	22	37	46
2	22	42	21	30	28	28	26	28	18	10	10	7	25	32	32	44	30	32	45	40	21	27	32	210
3	42	34	2	17	11	8	13	9	4	0	0	4	11	26	13	32	30	19	30	34	36	25	15	53
4	38	43	46	54	47	55	52	47	47	30	33	22	46	41	52	56	46	46	49	41	36	47	55	192
5	30	24	16	14	11	22	14	14	19	14	16	16	24	22	19	19	11	19	3	11	27	11	19	37
6	51	31	63	69	67	78	51	82	78	71	43	76	73	51	71	33	51	67	39	22	51	39	49	49
7	31	37	10	16	16	12	24	12	4	4	12	4	12	10	18	39	33	18	49	29	22	24	33	49
8	40	10	0	0	0	10	0	0	0	10	10	10	20	30	10	10	0	10	10	10	30	20	0	10
9	25	50	23	32	31	27	28	28	17	11	10	14	28	41	35	48	41	40	45	42	28	29	31	108
10	32	24	56	28	36	56	28	44	60	48	40	52	60	44	64	20	32	60	0	12	40	20	28	25
11	40	60	10	10	10	20	30	20	0	20	0	10	20	50	20	20	20	40	10	40	50	20	40	10
12	32	34	5	2	5	7	7	5	5	2	5	5	10	20	15	10	20	20	12	27	22	12	5	41
13	30	30	20	33	31	36	36	31	33	11	20	16	23	20	34	42	30	20	58	36	23	27	30	64
14	63	49	76	76	78	85	61	90	76	54	59	68	80	71	80	56	73	73	34	39	68	46	56	41
15	58	25	0	0	0	0	8	0	0	0	0	0	0	25	0	8	33	0	33	42	33	25	0	12
16	33	33	50	50	67	67	50	50	33	33	33	33	50	33	33	33	17	50	33	17	50	33	50	6
17	15	20	8	15	14	4	8	7	0	3	3	1	10	15	10	18	18	11	24	20	17	14	11	71
18	0	0	0	50	100	50	50	0	50	50	0	0	0	0	50	0	0	100	0	0	0	0	0	2

SURFACE MAP TYPE	XJ	YE	CT	EG	XD	RM	VG	QF	YC	QL	XH	PC	BA	JA	ET	MM	ZH	ZU	PY	OJ	QU	PE	OD	NUMBER OF CASES
19	46	23	49	49	46	77	34	74	77	69	51	80	71	46	57	14	34	54	17	9	49	31	34	35
20	59	32	73	73	68	64	64	77	82	59	55	59	77	64	77	41	50	82	23	36	59	55	55	22
21	60	100	20	20	20	0	20	20	0	0	0	0	20	20	20	20	40	20	20	40	60	20	0	5
22	0	100	100	100	100	100	100	100	0	100	100	0	100	100	100	100	100	0	100	0	100	100	0	1
23	81	75	38	50	63	88	25	75	63	50	31	50	56	56	81	38	56	81	13	31	75	81	19	16
24	100	75	25	63	63	63	38	63	25	25	0	38	75	88	88	38	88	100	25	50	88	88	75	8
25	37	58	63	63	58	68	63	58	63	53	32	58	63	63	58	58	47	53	21	26	21	32	79	19
26	8	8	12	19	23	15	0	15	12	19	8	19	12	4	4	15	15	12	27	8	4	19	12	26
27	14	22	8	3	5	14	5	11	16	16	8	22	24	19	27	8	8	19	0	8	11	11	11	37
28	25	46	23	13	19	19	21	15	13	13	10	13	19	27	21	38	31	31	40	40	21	25	27	48
29	20	0	0	0	0	0	0	20	0	0	0	0	20	0	0	0	40	0	20	20	0	0	40	5
30	11	11	61	56	56	72	44	67	61	89	72	83	72	22	56	44	39	50	28	11	28	17	44	18
31	75	88	13	63	75	50	38	50	0	0	13	38	63	75	38	63	75	63	38	75	88	88	63	8
32	63	56	31	50	56	50	38	50	50	44	25	44	63	63	63	44	63	75	25	44	63	56	44	16
33	33	44	0	11	22	0	11	0	0	0	0	11	11	44	22	44	56	33	33	56	44	56	33	9
U	31	35	27	33	31	39	29	36	32	30	23	31	38	33	40	39	36	33	28	28	36	31	37	492

APPENDIX 7

SUMMER 500 MB. - SURFACE MAP TYPE PoPs

The twenty-four hour percent probabilities of precipitation ($\geq$ 0.01 inches) are listed for each 500 mb. - surface combination. The number of cases used to calculate the probabilities are indicated for each map type combination (only $\geq$ ten cases are retained). The surface type labelled OTHER includes all surface map types which had fewer than ten occurrences initially. This classification is to be used when the surface type does not correspond to the significant combinations.

The station locations are shown in Figure 5 (page 52).

500 MB. MAP TYPE 1

SURFACE MAP TYPE	XJ	YE	CT	EG	XD	RM	VG	QF	YC	QL	XH	PC	BA	JA	ET	MM	ZH	ZU	PY	OJ	QU	PE	OD	NUMBER OF CASES
2	20	46	19	35	28	27	29	29	16	6	2	5	28	41	36	53	39	37	54	47	23	29	37	100
3	48	35	4	22	17	4	22	9	4	0	0	9	17	43	17	43	35	22	39	48	52	39	22	23
4	40	51	38	51	44	52	49	49	41	18	15	18	45	52	52	67	49	56	58	55	34	44	56	73
5	57	43	29	21	14	36	21	29	21	14	7	14	14	29	29	29	21	36	0	21	43	21	21	14
6	64	55	55	64	64	73	64	73	64	45	18	55	64	45	73	18	45	64	45	9	55	36	36	11
7	43	50	0	14	21	7	14	14	7	0	7	7	14	14	14	50	57	21	43	50	14	29	36	14
9	33	60	27	40	31	36	38	38	20	13	7	11	33	58	40	64	36	40	53	47	38	36	38	45
12	36	36	9	0	0	9	9	9	9	0	0	0	0	18	0	27	9	9	27	45	27	18	9	11
13	40	30	23	33	33	43	30	33	43	10	13	20	27	30	47	40	37	30	57	37	30	27	40	30
14	64	45	64	73	64	100	55	82	73	45	27	55	82	55	82	55	64	55	36	45	73	36	64	11
17	24	24	19	29	29	5	24	10	0	5	0	5	10	33	24	10	43	29	19	14	33	14	29	21
28	15	50	20	15	20	10	30	15	5	0	5	5	20	35	25	55	55	35	45	50	20	25	35	20
U	37	49	24	41	37	48	37	36	27	18	16	13	34	41	40	48	41	38	32	41	46	35	43	128
OTHER	46	44	25	37	35	45	24	37	24	24	10	24	32	46	48	32	46	54	27	34	49	45	37	71

500 MB. MAP TYPE 2

SURFACE MAP TYPE	XJ	YE	CT	EG	XD	RM	VG	QF	YC	QL	XH	PC	BA	JA	ET	MM	ZH	ZU	PY	DJ	QU	PE	OD	NUMBER OF CASES
2	14	29	17	14	28	18	14	20	5	2	12	0	9	23	23	38	15	31	34	38	14	18	25	65
3	21	37	0	5	0	5	0	11	0	0	0	0	5	11	5	21	21	11	32	26	26	11	5	19
4	19	36	36	33	44	44	36	39	31	8	33	3	28	22	31	47	33	19	42	22	17	39	42	36
7	22	39	9	9	13	9	17	4	0	0	13	0	9	4	4	30	30	9	30	30	9	17	26	23
9	17	48	7	17	24	10	7	14	10	7	7	14	14	24	28	41	38	34	34	48	17	24	24	29
12	36	36	9	9	18	9	9	0	9	0	0	0	18	27	18	9	36	27	36	55	36	27	9	11
13	11	17	11	28	28	33	39	17	28	0	11	0	17	11	28	39	6	17	44	17	11	17	17	18
17	16	24	8	12	12	4	4	4	0	0	0	0	8	12	8	28	4	8	28	24	12	24	12	25
28	32	50	18	9	27	18	14	9	0	0	9	0	9	32	23	36	18	27	32	55	23	18	27	22
U	19	29	16	22	16	18	19	18	10	11	4	10	6	15	20	33	24	19	22	26	21	21	26	89
OTHER	27	30	16	25	25	30	14	16	16	7	5	11	25	16	34	25	27	36	20	25	25	16	27	44

500 MB. MAP TYPE 3

SURFACE MAP TYPE	XJ	YE	CT	EG	XD	RM	VG	QF	YC	QL	XH	PC	BA	JA	ET	MM	ZH	ZU	PY	OJ	QU	PE	OD	NUMBER OF CASES
2	35	35	29	48	35	42	39	39	35	13	13	10	58	58	39	48	39	39	55	55	29	42	42	31
4	47	57	33	63	50	63	63	47	47	30	23	20	70	53	57	80	63	57	53	57	53	53	73	30
9	47	58	37	47	42	53	32	47	26	16	21	16	58	68	42	74	53	42	63	53	37	32	37	19
U	41	41	30	46	40	53	38	49	32	23	20	28	53	46	58	53	58	59	36	43	52	44	57	81
OTHER	66	52	37	51	51	54	46	61	40	29	32	35	56	67	59	48	61	57	30	35	76	55	45	82

500 MB. MAP TYPE 4

SURFACE MAP TYPE	XJ	YE	CT	EG	XD	RM	VG	QF	YC	QL	XH	PC	BA	JA	ET	MM	ZH	ZU	PY	OJ	QU	PE	OD	NUMBER OF CASES
2	25	33	25	33	25	25	25	25	42	17	8	8	42	25	42	58	50	25	25	33	25	50	33	12
4	47	40	53	47	53	47	53	47	87	47	27	27	60	33	40	60	60	40	40	27	67	67	67	15
U	41	46	27	41	30	49	30	43	57	43	22	46	49	43	43	43	38	30	38	38	41	46	41	37
OTHER	35	23	46	46	46	52	42	44	44	33	29	38	46	25	48	44	42	50	38	29	31	33	37	52

500 MB. MAP TYPE 5

SURFACE MAP TYPE	XJ	YE	CT	EG	XD	RM	VG	QF	YC	QL	XH	PC	BA	JA	ET	MM	ZH	ZU	PY	OJ	QU	PE	OD	NUMBER OF CASES
2	15	46	46	38	31	38	38	46	62	31	31	23	46	23	54	31	15	38	38	15	23	0	46	13
9	14	57	29	29	36	21	14	29	29	14	21	14	36	43	43	29	36	36	36	29	36	14	29	14
U	25	38	38	38	33	42	33	42	50	38	38	46	54	33	38	50	38	46	42	21	29	38	50	24
OTHER	33	41	26	26	26	21	28	21	38	31	31	31	44	33	33	21	31	23	28	21	23	13	33	39

500 MB. MAP TYPE 6

SURFACE MAP TYPE	XJ	YE	CT	EG	XD	RM	VG	QF	YC	QL	XH	PC	BA	JA	ET	MM	ZH	ZU	PY	OJ	QU	PE	OD	NUMBER OF CASES
U	13	17	25	17	25	13	25	8	17	13	4	13	8	4	17	46	29	17	29	4	8	8	42	24
OTHER	19	28	25	22	22	31	16	31	31	31	19	31	34	22	34	47	9	25	31	25	22	16	19	32

500 MB. MAP TYPE 7

SURFACE MAP TYPE	XJ	YE	CT	EG	XD	RM	VG	QF	YC	QL	XH	PC	BA	JA	ET	MM	ZH	ZU	PY	OJ	QU	PE	OD	NUMBER OF CASES
4	58	42	42	83	83	50	58	42	50	25	25	17	67	33	75	50	75	58	50	42	42	33	67	12
U	82	27	55	82	64	64	36	45	55	27	9	27	73	55	73	55	73	73	45	36	73	82	45	11
OTHER	61	39	57	74	78	78	70	78	70	39	57	65	70	52	57	48	74	61	26	26	70	61	65	23

500 MB. MAP TYPE 8

SURFACE MAP TYPE	XJ	YE	CT	EG	XD	RM	VG	QF	YC	QL	XH	PC	BA	JA	ET	MM	ZH	ZU	PY	OJ	QU	PE	OD	NUMBER OF CASES
2	13	54	25	29	33	21	21	29	13	17	8	4	17	29	21	29	38	38	25	29	21	0	17	24
3	42	21	0	4	4	0	8	0	0	0	0	0	0	21	4	21	25	13	13	13	25	17	4	24
5	38	46	8	0	0	15	8	8	15	0	0	0	8	15	0	15	0	0	0	15	38	8	15	13
9	13	63	13	30	33	17	17	13	17	23	7	17	30	37	30	27	37	30	43	37	27	23	23	30
12	45	41	9	5	9	9	14	5	9	0	5	5	9	18	14	14	23	27	9	32	27	14	9	22
17	14	29	7	7	7	0	21	7	0	0	0	0	0	14	7	7	36	21	7	7	21	7	14	14
U	37	50	15	29	29	31	23	21	17	10	10	10	31	44	37	40	33	29	31	38	52	44	37	52
OTHER	39	38	18	18	16	20	14	18	20	18	7	14	20	32	27	18	25	29	25	27	36	27	20	56

500 MB. MAP TYPE 9

SURFACE MAP TYPE	XJ	YE	CT	EG	XD	RM	VG	QF	YC	QL	XH	PC	BA	JA	ET	MM	ZH	ZU	PY	OJ	QU	PE	OD	NUMBER OF CASES
OTHER	31	13	50	63	56	63	56	56	56	69	69	69	75	63	81	44	50	69	31	31	63	38	50	16

500 MB. MAP TYPE 10

SURFACE MAP TYPE	XJ	YE	CT	EG	XD	RM	VG	QF	YC	QL	XH	PC	BA	JA	ET	MM	ZH	ZU	PY	OJ	QU	PE	OD	NUMBER OF CASES
U	0	0	10	20	0	10	10	20	20	20	10	20	20	10	0	20	10	0	10	10	0	10	10	10
OTHER	8	23	8	8	15	46	0	46	54	54	8	69	23	15	31	8	8	15	0	8	15	15	0	13

500 MB. MAP TYPE 11

SURFACE MAP TYPE	XJ	YE	CT	EG	XD	RM	VG	QF	YC	QL	XH	PC	BA	JA	ET	MM	ZH	ZU	PY	OJ	QU	PE	OD	NUMBER OF CASES
2	27	43	30	47	30	43	27	47	17	10	17	3	33	43	50	57	23	47	40	40	20	23	23	30
4	36	43	46	50	43	57	50	43	32	18	21	11	36	32	50	46	36	36	43	21	25	46	36	28
9	58	75	17	50	42	33	58	50	33	0	17	17	42	75	50	58	58	67	58	83	50	58	33	12
U	33	37	30	22	30	33	22	30	19	11	19	15	30	22	30	52	33	30	26	48	30	30	30	27
OTHER	48	50	17	28	22	22	37	22	19	9	19	11	26	30	35	39	43	37	37	44	33	46	43	54

500 MB. MAP TYPE 12

SURFACE MAP TYPE	XJ	YE	CT	EG	XD	RM	VG	QF	YC	QL	XH	PC	BA	JA	ET	MM	ZH	ZU	PY	OJ	QU	PE	OD	NUMBER OF CASES
OTHER	53	32	53	53	47	76	42	71	76	32	29	53	63	34	66	18	53	50	34	16	55	39	32	38

500 MB. MAP TYPE 13

SURFACE MAP TYPE	XJ	YE	CT	EG	XD	RM	VG	QF	YC	QL	XH	PC	BA	JA	ET	MM	ZH	ZU	PY	OJ	QU	PE	OD	NUMBER OF CASES
OTHER	0	25	33	42	42	67	50	67	75	58	58	75	75	33	42	58	17	25	8	8	8	17	67	12

500 MB. MAP TYPE 14

SURFACE MAP TYPE	XJ	YE	CT	EG	XD	RM	VG	QF	YC	QL	XH	PC	BA	JA	ET	MM	ZH	ZU	PY	OJ	QU	PE	OD	NUMBER OF CASES
U	31	19	50	25	44	19	38	44	38	50	38	63	38	19	25	50	50	31	38	13	31	25	38	16
OTHER	26	29	40	46	37	49	49	46	26	37	34	29	23	20	31	49	37	26	60	37	29	40	43	35

500 MB. MAP TYPE 15

SURFACE MAP TYPE	XJ	YE	CT	EG	XD	RM	VG	QF	YC	QL	XH	PC	BA	JA	ET	MM	ZH	ZU	PY	OJ	QU	PE	OD	NUMBER OF CASES
2	45	64	18	55	36	45	55	36	9	0	0	9	27	27	55	91	64	45	73	82	45	64	73	11
4	53	43	60	63	57	53	67	57	50	33	37	17	40	37	60	60	57	63	63	53	50	53	73	30
U	55	45	36	64	45	73	64	55	73	73	45	45	55	36	36	64	64	45	45	18	73	64	82	11
OTHER	78	37	67	56	74	59	67	70	63	52	52	44	63	63	67	56	74	74	48	56	70	59	70	27

500 MB. MAP TYPE 16

SURFACE MAP TYPE	XJ	YE	CT	EG	XD	RM	VG	QF	YC	QL	XH	PC	BA	JA	ET	MM	ZH	ZU	PY	OJ	QU	PE	OD	NUMBER OF CASES
2	18	55	9	0	0	9	0	18	0	0	9	0	0	9	0	27	0	9	36	27	18	18	27	11
9	27	64	9	18	9	9	18	18	0	0	0	0	9	9	9	45	27	45	55	27	18	9	18	11
U	10	40	10	30	20	10	50	30	10	30	20	20	20	30	20	30	20	20	10	0	10	10	30	10
OTHER	17	37	3	11	9	11	3	11	0	0	3	0	3	6	3	17	14	9	23	23	23	23	17	35

500 MB. MAP TYPE 17

SURFACE MAP TYPE	XJ	YE	CT	EG	XD	RM	VG	QF	YC	QL	XH	PC	BA	JA	ET	MM	ZH	ZU	PY	OJ	QU	PE	OD	NUMBER OF CASES
U	10	50	40	40	30	60	40	60	30	40	20	60	50	30	30	50	60	30	50	30	30	30	60	10
OTHER	31	25	50	44	56	50	44	50	56	50	44	50	50	6	50	50	50	75	38	13	44	44	50	16

500 MB. MAP TYPE 18

SURFACE MAP TYPE	XJ	YE	CT	EG	XD	RM	VG	QF	YC	QL	XH	PC	BA	JA	ET	MM	ZH	ZU	PY	OJ	QU	PE	OD	NUMBER OF CASES
OTHER	26	17	17	20	29	26	14	20	17	11	9	6	43	49	40	37	26	43	17	40	29	11	23	35

500 MB. MAP TYPE 19

SURFACE MAP TYPE	XJ	YE	CT	EG	XD	RM	VG	QF	YC	QL	XH	PC	BA	JA	ET	MM	ZH	ZU	PY	OJ	QU	PE	OD	NUMBER OF CASES
U	19	27	31	31	31	46	31	35	38	23	27	27	58	35	54	35	27	31	15	23	31	23	27	26
OTHER	31	36	38	27	27	42	22	31	20	33	24	27	24	53	36	11	24	40	13	22	38	18	18	45

500 MB. MAP TYPE 20

SURFACE MAP TYPE	XJ	YE	CT	EG	XD	RM	VG	QF	YC	QL	XH	PC	BA	JA	ET	MM	ZH	ZU	PY	OJ	QU	PE	OD	NUMBER OF CASES
OTHER	0	0	0	12	0	12	12	12	0	0	6	0	0	0	0	12	0	0	0	0	0	12	0	17

500 MB. MAP TYPE 21

SURFACE MAP TYPE	XJ	YE	CT	EG	XD	RM	VG	QF	YC	QL	XH	PC	BA	JA	ET	MM	ZH	ZU	PY	OJ	QU	PE	OD	NUMBER OF CASES
OTHER	48	29	67	48	43	81	71	86	81	52	52	62	76	33	71	48	19	29	52	19	38	24	62	21

500 MB. MAP TYPE 22

SURFACE MAP TYPE	XJ	YE	CT	EG	XD	RM	VG	QF	YC	QL	XH	PC	BA	JA	ET	MM	ZH	ZU	PY	OJ	QU	PE	OD	NUMBER OF CASES
U	58	58	25	50	58	75	33	42	58	33	33	58	83	67	92	42	75	75	17	25	83	58	58	12
OTHER	78	56	11	78	56	44	11	33	33	22	22	22	67	56	89	33	89	89	33	67	67	67	33	9

500 MB. MAP TYPE 23

SURFACE MAP TYPE	XJ	YE	CT	EG	XD	RM	VG	QF	YC	QL	XH	PC	BA	JA	ET	MM	ZH	ZU	PY	OJ	QU	PE	OD	NUMBER OF CASES
OTHER	19	19	5	29	19	38	19	19	14	14	14	14	19	10	10	33	24	19	29	19	10	33	14	21

500 MB. MAP TYPE 24

SURFACE MAP TYPE	XJ	YE	CT	EG	XD	RM	VG	QF	YC	QL	XH	PC	BA	JA	ET	MM	ZH	ZU	PY	OJ	QU	PE	OD	NUMBER OF CASES
OTHER	31	15	46	69	69	85	54	77	77	85	85	62	85	54	77	54	62	69	31	15	69	15	46	13

500 MB. MAP TYPE 25

SURFACE MAP TYPE	XJ	YE	CT	EG	XD	RM	VG	QF	YC	QL	XH	PC	BA	JA	ET	MM	ZH	ZU	PY	OJ	QU	PE	OD	NUMBER OF CASES
2	15	36	9	12	6	6	12	12	12	6	3	6	15	21	24	45	30	21	61	27	15	18	27	33
4	22	39	28	39	33	67	33	50	44	11	22	28	33	39	61	50	44	50	67	39	17	28	39	18
13	11	11	0	39	22	39	22	17	22	6	11	11	6	17	39	22	6	17	44	33	6	6	17	18
28	18	55	27	9	9	9	18	27	18	27	18	36	36	27	9	45	55	27	45	18	9	9	27	11
U	18	29	18	12	18	35	18	29	18	18	0	18	12	35	29	18	41	35	29	18	24	18	29	17
OTHER	28	44	14	26	30	19	16	16	14	21	7	16	19	9	21	35	40	28	49	33	26	21	35	43

500 MB. MAP TYPE 26

SURFACE MAP TYPE	XJ	YE	CT	EG	XD	RM	VG	QF	YC	QL	XH	PC	BA	JA	ET	MM	ZH	ZU	PY	OJ	QU	PE	OD	NUMBER OF CASES
U	65	65	12	24	18	29	18	12	6	6	12	12	53	53	59	35	53	47	18	47	65	71	29	17
OTHER	50	36	23	18	14	27	5	14	9	9	5	14	9	23	23	41	32	27	9	32	36	18	9	22

500 MB. MAP TYPE 27

SURFACE MAP TYPE	XJ	YE	CT	EG	XD	RM	VG	QF	YC	QL	XH	PC	BA	JA	ET	MM	ZH	ZU	PY	OJ	QU	PE	OD	NUMBER OF CASES
OTHER	20	30	30	40	30	70	10	40	70	70	40	40	70	40	40	40	50	40	60	20	30	30	30	10

500 MB. MAP TYPE 28

SURFACE MAP TYPE	XJ	YE	CT	EG	XD	RM	VG	QF	YC	QL	XH	PC	BA	JA	ET	MM	ZH	ZU	PY	OJ	QU	PE	OD	NUMBER OF CASES
U	15	18	12	12	15	18	12	12	15	15	6	9	12	6	21	18	15	21	21	18	15	21	32	34
OTHER	21	32	7	11	7	21	11	21	25	11	4	14	14	7	18	25	14	25	11	14	11	14	29	28

500 MB. MAP TYPE 29

SURFACE MAP TYPE	XJ	YE	CT	EG	XD	RM	VG	QF	YC	QL	XH	PC	BA	JA	ET	MM	ZH	ZU	PY	OJ	QU	PE	OD	NUMBER OF CASES
OTHER	0	0	27	18	9	9	0	36	18	27	36	18	9	9	0	45	27	0	18	9	9	0	18	11

500 MB. MAP TYPE 30

SURFACE MAP TYPE	XJ	YE	CT	EG	XD	RM	VG	QF	YC	QL	XH	PC	BA	JA	ET	MM	ZH	ZU	PY	OJ	QU	PE	OD	NUMBER OF CASES
OTHER	33	24	52	24	33	48	48	48	38	43	48	24	33	33	29	29	38	43	29	33	19	24	67	21

500 MB. MAP TYPE 31

SURFACE MAP TYPE	XJ	YE	CT	EG	XD	RM	VG	QF	YC	QL	XH	PC	BA	JA	ET	MM	ZH	ZU	PY	OJ	QU	PE	OD	NUMBER OF CASES
OTHER	38	0	50	63	63	63	50	88	75	63	38	50	75	25	50	13	50	38	13	13	25	13	38	8

500 MB. MAP TYPE 32

SURFACE MAP TYPE	XJ	YE	CT	EG	XD	RM	VG	QF	YC	QL	XH	PC	BA	JA	ET	MM	ZH	ZU	PY	OJ	QU	PE	OD	NUMBER OF CASES
OTHER	19	31	81	63	56	81	44	81	63	69	50	75	75	25	75	38	44	50	63	19	25	19	44	16

500 MB. MAP TYPE 33

SURFACE MAP TYPE	XJ	YE	CT	EG	XD	RM	VG	QF	YC	QL	XH	PC	BA	JA	ET	MM	ZH	ZU	PY	OJ	QU	PE	OD	NUMBER OF CASES
4	30	30	60	60	30	60	60	70	30	60	60	10	70	40	50	40	30	40	50	40	20	50	60	10
OTHER	25	13	63	63	56	63	50	63	63	56	56	50	38	31	44	63	38	44	63	19	19	44	25	16

500 MB. MAP TYPE 34

SURFACE MAP TYPE	XJ	YE	CT	EG	XD	RM	VG	QF	YC	QL	XH	PC	BA	JA	ET	MM	ZH	ZU	PY	OJ	QU	PE	OD	NUMBER OF CASES
OTHER	25	50	50	25	25	75	25	50	25	100	75	100	50	50	25	25	75	75	25	25	25	0	50	4

500 MB. MAP TYPE 35

SURFACE MAP TYPE	XJ	YE	CT	EG	XD	RM	VG	QF	YC	QL	XH	PC	BA	JA	ET	MM	ZH	ZU	PY	OJ	QU	PE	OD	NUMBER OF CASES
OTHER	53	24	59	59	65	65	41	47	59	29	24	47	59	41	88	35	47	76	29	35	47	59	24	17

500 MB. MAP TYPE U

SURFACE MAP TYPE	XJ	YE	CT	EG	XD	RM	VG	QF	YC	QL	XH	PC	BA	JA	ET	MM	ZH	ZU	PY	OJ	QU	PE	OD	NUMBER OF CASES
4	40	47	60	60	47	53	60	40	67	53	53	60	60	47	60	40	53	47	40	33	40	47	60	15
6	62	38	69	69	62	77	46	85	77	100	54	100	85	77	77	46	46	77	38	46	38	54	54	13
14	60	60	80	80	90	80	80	90	60	70	70	90	80	80	80	40	70	80	10	30	50	40	50	10
19	57	21	57	36	36	71	21	71	71	79	57	100	86	57	57	7	14	57	7	14	50	43	14	14
U	36	28	24	27	30	42	28	37	40	52	39	54	46	33	40	21	21	22	21	19	33	16	21	67
OTHER	23	32	38	29	27	44	14	40	40	41	32	49	47	38	38	15	15	30	14	15	22	18	16	73

APPENDIX 8

SUMMER 500 MB. - 500 MB. MAP TYPE PoPs

The twenty-four hour percent probabilities of precipitation (≥ 0.01 inches) are listed for each 500 mb. - 500 mb. combination. The combinations use the initial 500 mb. map type and the following twelve-hour 500 mb. map type, to distinguish weather system motions. The number of cases used to calculate the probabilities are indicated for each map type combination (only $\geq$ ten cases are retained). The following twelve-hour 500 mb. map type labelled OTHER includes all 500 mb. map types which had fewer than ten occurrences initially. This last classification is to be used when the following 500 mb. map does not correspond to any significant 500 mb. map type.

The station locations are shown in Figure 5 (page 52).

INITIAL 500 MB. MAP TYPE 1

500 MB. MAP TYPE	XJ	YE	CT	EG	XD	RM	VG	QF	YC	QL	XH	PC	BA	JA	ET	MM	ZH	ZU	PY	OJ	QU	PE	OD	NUMBER OF CASES
1	36	48	24	36	33	35	34	33	21	10	7	9	30	43	40	51	42	42	42	41	41	34	38	328
2	16	32	18	29	29	25	19	23	17	14	8	13	18	29	27	43	35	23	40	43	17	30	32	77
3	45	54	21	40	33	41	29	38	20	15	10	15	40	45	45	45	48	44	36	41	55	43	34	97
4	65	60	35	40	45	70	40	50	60	35	35	50	50	55	55	65	75	40	60	65	45	70	75	20
5	36	73	27	36	9	55	18	55	27	18	9	27	36	36	36	45	27	27	18	36	55	36	36	11
8	33	35	18	29	25	25	26	22	15	7	4	8	22	32	28	47	35	25	24	24	39	22	28	72
11	42	63	24	50	34	37	37	39	21	3	13	11	39	58	53	53	42	53	53	45	47	37	37	38
15	62	62	62	73	57	84	62	70	68	38	32	30	70	65	57	62	57	62	43	59	49	59	68	37
19	13	38	13	13	13	19	13	0	13	6	0	13	19	25	6	13	6	19	19	31	0	6	6	16
25	27	48	25	29	25	33	38	25	10	13	2	6	10	33	38	33	44	44	46	40	42	23	44	48
OTHER	46	39	37	44	49	61	34	49	56	31	25	31	51	44	58	46	46	53	36	42	41	34	46	59

INITIAL 500 MB. MAP TYPE 2

500 MB. MAP TYPE	XJ	YE	CT	EG	XD	RM	VG	QF	YC	QL	XH	PC	BA	JA	ET	MM	ZH	ZU	PY	OJ	QU	PE	OD	NUMBER OF CASES
1	28	45	16	22	24	13	19	11	12	3	4	3	7	24	21	37	24	27	37	45	28	24	22	94
2	16	29	14	20	24	19	17	17	11	7	9	7	10	14	20	32	25	21	29	31	15	23	29	198
8	14	32	7	8	12	5	3	8	5	7	5	5	5	5	3	14	14	15	15	12	15	7	2	59
11	29	42	22	24	24	27	29	27	16	0	20	4	31	29	29	58	42	33	42	40	27	29	40	45
16	13	25	8	17	13	13	21	8	0	8	8	13	8	17	8	13	8	0	13	17	13	21	25	24
25	35	47	6	24	24	12	29	12	12	12	6	6	18	29	29	35	24	41	35	41	35	24	24	17
28	10	21	14	17	21	21	14	10	7	14	3	3	7	3	28	41	31	24	17	31	17	34	45	29
OTHER	30	23	30	28	32	49	21	38	28	9	13	17	26	26	43	34	21	32	32	23	32	17	26	47

INITIAL 500 MB. MAP TYPE 3

500 MB. MAP TYPE	XJ	YE	CT	EG	XD	RM	VG	QF	YC	QL	XH	PC	BA	JA	ET	MM	ZH	ZU	PY	OJ	QU	PE	OD	NUMBER OF CASES
1	42	50	25	50	43	50	43	46	27	12	10	12	56	61	45	62	56	52	50	55	55	46	49	84
3	52	51	26	45	41	48	39	48	21	18	19	24	51	59	54	53	59	54	38	47	57	48	44	140
5	42	58	58	50	33	50	25	58	33	58	50	50	67	42	50	42	58	50	33	42	58	50	33	12
7	66	48	41	72	69	62	55	69	41	24	34	31	69	55	72	55	76	69	34	48	66	55	66	29
15	44	72	44	67	56	78	61	50	56	17	22	17	83	72	67	67	72	61	39	44	56	56	78	18
21	64	36	64	73	73	73	55	82	64	73	55	82	73	18	36	64	36	27	45	18	45	27	64	11
OTHER	51	40	34	55	51	62	42	55	60	34	26	38	64	53	60	51	62	60	36	34	58	51	68	53

INITIAL 500 MB. MAP TYPE 4

500 MB. MAP TYPE	XJ	YE	CT	EG	XD	RM	VG	QF	YC	QL	XH	PC	BA	JA	ET	MM	ZH	ZU	PY	OJ	QU	PE	OD	NUMBER OF CASES
1	31	38	38	38	38	62	46	46	31	31	15	23	38	46	62	62	38	46	23	38	31	38	46	13
2	38	42	38	63	46	42	38	46	50	38	29	29	42	29	46	58	42	42	29	42	42	46	50	24
4	48	40	37	40	37	50	37	38	65	37	19	46	46	35	44	54	50	35	42	29	44	48	50	52
28	18	9	18	36	36	18	36	18	27	9	9	0	18	27	27	36	36	36	36	18	36	27	55	11
OTHER	33	37	45	49	43	55	45	53	55	43	29	43	59	35	47	41	41	45	47	41	35	47	31	51

INITIAL 500 MB. MAP TYPE 5

500 MB. MAP TYPE	XJ	YE	CT	EG	XD	RM	VG	QF	YC	QL	XH	PC	BA	JA	ET	MM	ZH	ZU	PY	OJ	QU	PE	OD	NUMBER OF CASES
1	20	45	30	25	40	20	30	25	35	30	15	30	60	35	30	30	45	30	55	40	30	20	45	20
3	25	50	33	33	42	33	17	17	33	25	17	33	50	33	42	25	58	25	42	33	33	17	33	12
5	33	48	22	30	19	26	22	33	33	19	37	33	37	33	44	22	26	33	19	11	30	22	26	27
8	25	38	25	17	13	13	29	29	29	21	25	21	33	29	21	29	17	25	13	17	21	25	29	24
OTHER	30	39	39	42	45	52	36	39	67	39	39	42	67	39	52	48	33	39	48	21	27	18	52	33

INITIAL 500 MB. MAP TYPE 6

500 MB. MAP TYPE	XJ	YE	CT	EG	XD	RM	VG	QF	YC	QL	XH	PC	BA	JA	ET	MM	ZH	ZU	PY	OJ	QU	PE	OD	NUMBER OF CASES
6	21	18	24	21	21	21	21	21	24	24	12	21	18	6	24	42	18	21	27	9	15	12	36	33
14	27	18	45	27	36	18	36	18	27	27	18	36	36	9	36	45	45	36	45	9	18	18	36	11
28	12	29	24	18	18	24	18	18	24	6	12	6	6	12	18	24	12	24	29	12	12	12	29	17
OTHER	17	26	17	13	22	30	9	26	30	26	13	30	22	30	30	39	22	17	26	30	22	22	17	23

INITIAL 500 MB. MAP TYPE 7

500 MB. MAP TYPE	XJ	YE	CT	EG	XD	RM	VG	QF	YC	QL	XH	PC	BA	JA	ET	MM	ZH	ZU	PY	OJ	QU	PE	OD	NUMBER OF CASES
7	57	36	50	86	86	57	64	71	57	36	36	43	79	64	71	50	93	71	43	21	79	64	71	14
OTHER	73	33	44	78	76	62	51	53	49	27	27	38	64	38	64	51	71	62	38	33	58	58	58	45

INITIAL 500 MB. MAP TYPE 8

500 MB. MAP TYPE	XJ	YE	CT	EG	XD	RM	VG	QF	YC	QL	XH	PC	BA	JA	ET	MM	ZH	ZU	PY	OJ	QU	PE	OD	NUMBER OF CASES
1	35	54	18	25	25	21	21	19	17	10	6	9	23	36	29	37	36	29	33	36	48	32	30	107
2	18	59	9	14	18	14	5	5	14	14	5	14	14	14	18	23	18	27	36	32	23	23	14	22
3	56	67	28	28	22	33	17	11	28	22	11	17	17	50	39	28	39	28	22	39	61	44	39	18
5	30	40	5	5	5	15	15	10	10	5	15	5	20	25	30	15	15	20	15	30	30	35	15	20
8	28	35	14	20	19	18	18	18	13	9	8	8	21	28	24	28	30	26	16	24	35	22	20	120
25	20	80	10	30	50	30	20	10	10	30	0	30	20	30	30	0	30	10	90	40	30	30	20	10
26	54	31	0	8	8	8	0	15	23	15	0	15	23	38	23	8	23	31	15	15	23	31	15	13
OTHER	29	57	24	19	19	24	14	19	33	19	14	10	33	57	33	24	24	43	24	43	38	29	24	21

INITIAL 500 MB. MAP TYPE 9

500 MB. MAP TYPE	XJ	YE	CT	EG	XD	RM	VG	QF	YC	QL	XH	PC	BA	JA	ET	MM	ZH	ZU	PY	OJ	QU	PE	OD	NUMBER OF CASES
OTHER	32	16	58	58	53	58	53	53	53	68	58	68	74	63	79	37	47	74	37	26	58	42	47	19

INITIAL 500 MB. MAP TYPE 10

500 MB. MAP TYPE	XJ	YE	CT	EG	XD	RM	VG	QF	YC	QL	XH	PC	BA	JA	ET	MM	ZH	ZU	PY	OJ	QU	PE	OD	NUMBER OF CASES
10	9	18	9	18	9	36	9	45	45	45	9	55	18	18	18	9	9	9	9	9	9	18	9	11
OTHER	8	8	17	17	0	25	8	25	33	33	17	33	17	25	17	17	8	0	0	17	0	0	8	12

INITIAL 500 MB. MAP TYPE 11

500 MB. MAP TYPE	XJ	YE	CT	EG	XD	RM	VG	QF	YC	QL	XH	PC	BA	JA	ET	MM	ZH	ZU	PY	OJ	QU	PE	OD	NUMBER OF CASES
1	34	56	20	37	29	32	34	32	10	5	5	5	27	44	51	54	37	51	37	56	39	41	32	41
2	27	37	24	24	27	24	37	24	20	7	20	10	20	15	24	39	41	29	24	32	17	41	39	41
4	64	82	45	55	55	73	36	55	64	27	55	36	55	64	64	73	45	45	64	64	45	64	45	11
11	43	46	25	40	34	39	42	42	21	13	22	9	34	40	43	46	39	45	37	39	37	39	36	67
OTHER	46	29	40	31	34	37	29	37	34	20	26	29	29	23	40	49	26	31	37	46	29	37	37	35

INITIAL 500 MB. MAP TYPE 12

500 MB. MAP TYPE	XJ	YE	CT	EG	XD	RM	VG	QF	YC	QL	XH	PC	BA	JA	ET	MM	ZH	ZU	PY	OJ	QU	PE	OD	NUMBER OF CASES
12	57	36	50	43	43	79	36	64	86	29	36	36	71	29	57	14	57	36	43	29	57	64	21	14
OTHER	48	26	48	55	52	77	48	71	65	23	19	52	65	39	74	29	55	58	32	19	48	32	39	31

INITIAL 500 MB. MAP TYPE 13

500 MB. MAP TYPE	XJ	YE	CT	EG	XD	RM	VG	QF	YC	QL	XH	PC	BA	JA	ET	MM	ZH	ZU	PY	OJ	QU	PE	OD	NUMBER OF CASES
OTHER	0	29	21	43	36	71	43	71	71	57	57	71	79	36	50	50	14	21	7	14	7	21	64	14

INITIAL 500 MB. MAP TYPE 14

500 MB. MAP TYPE	XJ	YE	CT	EG	XD	RM	VG	QF	YC	QL	XH	PC	BA	JA	ET	MM	ZH	ZU	PY	OJ	QU	PE	OD	NUMBER OF CASES
6	29	14	43	36	36	50	43	36	29	43	29	43	29	0	21	50	36	36	50	14	29	21	43	14
14	33	29	50	46	54	46	54	42	38	46	29	46	38	21	38	63	54	42	50	21	33	38	54	24
OTHER	21	25	43	39	39	36	39	54	32	39	46	36	18	32	32	25	29	21	39	43	32	39	32	28

INITIAL 500 MB. MAP TYPE 15

500 MB. MAP TYPE	XJ	YE	CT	EG	XD	RM	VG	QF	YC	QL	XH	PC	BA	JA	ET	MM	ZH	ZU	PY	OJ	QU	PE	OD	NUMBER OF CASES
1	48	52	43	57	52	48	61	57	35	22	22	4	39	43	57	74	61	70	57	48	52	57	61	23
2	45	18	55	64	55	45	64	55	55	55	45	18	27	27	64	27	73	55	45	45	55	64	73	11
4	73	40	47	60	67	60	60	53	60	40	33	33	47	53	47	60	67	60	53	60	67	67	80	15
15	68	54	68	71	61	68	71	68	75	50	50	32	54	57	50	61	68	64	61	57	54	54	64	28
OTHER	60	47	50	57	50	53	53	57	47	50	40	43	60	37	57	67	63	53	57	43	73	57	73	30

INITIAL 500 MB. MAP TYPE 16

500 MB. MAP TYPE	XJ	YE	CT	EG	XD	RM	VG	QF	YC	QL	XH	PC	BA	JA	ET	MM	ZH	ZU	PY	OJ	QU	PE	OD	NUMBER OF CASES
2	18	48	6	18	12	12	15	21	3	6	9	6	6	12	6	27	18	18	24	21	21	21	27	33
16	13	26	4	9	4	4	13	4	0	4	4	4	0	4	0	17	4	4	17	17	13	13	17	23
OTHER	14	52	5	10	5	10	10	19	5	5	5	0	10	10	10	29	14	19	29	19	14	14	19	21

INITIAL 500 MB. MAP TYPE 17

500 MB. MAP TYPE	XJ	YE	CT	EG	XD	RM	VG	QF	YC	QL	XH	PC	BA	JA	ET	MM	ZH	ZU	PY	OJ	QU	PE	OD	NUMBER OF CASES
17	17	42	67	50	50	67	42	75	42	50	42	67	67	25	50	58	67	50	50	17	50	50	67	12
OTHER	25	38	38	31	25	44	38	44	50	50	19	50	44	13	31	31	38	44	25	25	25	25	38	16

INITIAL 500 MB. MAP TYPE 18

500 MB. MAP TYPE	XJ	YE	CT	EG	XD	RM	VG	QF	YC	QL	XH	PC	BA	JA	ET	MM	ZH	ZU	PY	OJ	QU	PE	OD	NUMBER OF CASES
1	27	36	9	18	18	27	18	9	0	0	0	9	36	27	36	45	27	45	18	55	27	18	27	11
18	27	0	18	18	18	27	18	9	9	9	0	9	27	45	36	36	0	27	18	18	27	0	9	11
OTHER	23	23	5	18	27	23	5	23	23	9	14	5	45	45	32	36	27	41	23	36	41	14	23	22

INITIAL 500 MB. MAP TYPE 19

500 MB. MAP TYPE	XJ	YE	CT	EG	XD	RM	VG	QF	YC	QL	XH	PC	BA	JA	ET	MM	ZH	ZU	PY	OJ	QU	PE	OD	NUMBER OF CASES
1	19	25	25	44	38	63	31	38	31	13	13	19	38	50	50	31	31	44	19	31	25	13	31	16
3	31	38	38	13	25	31	19	31	19	38	25	25	31	44	44	19	38	38	0	13	56	38	19	16
19	17	35	17	22	22	35	17	13	26	26	30	17	39	43	35	17	22	30	17	13	26	13	17	23
OTHER	25	28	38	30	30	50	25	48	35	30	30	33	45	43	53	23	28	38	18	23	35	18	23	40

INITIAL 500 MB. MAP TYPE 20

500 MB. MAP TYPE	XJ	YE	CT	EG	XD	RM	VG	QF	YC	QL	XH	PC	BA	JA	ET	MM	ZH	ZU	PY	OJ	QU	PE	OD	NUMBER OF CASES
OTHER	0	0	0	8	0	8	8	8	0	0	8	0	0	0	0	8	0	0	0	0	0	8	0	13

INITIAL 500 MB. MAP TYPE 21

500 MB. MAP TYPE	XJ	YE	CT	EG	XD	RM	VG	QF	YC	QL	XH	PC	BA	JA	ET	MM	ZH	ZU	PY	OJ	QU	PE	OD	NUMBER OF CASES
OTHER	43	35	57	48	48	78	70	83	70	43	39	57	78	39	78	52	22	35	48	22	30	35	61	23

INITIAL 500 MB. MAP TYPE 22

500 MB. MAP TYPE	XJ	YE	CT	EG	XD	RM	VG	QF	YC	QL	XH	PC	BA	JA	ET	MM	ZH	ZU	PY	OJ	QU	PE	OD	NUMBER OF CASES
3	60	30	30	60	60	50	40	40	40	10	40	40	90	70	90	70	100	90	40	30	60	70	80	10
OTHER	63	69	25	63	63	81	31	44	63	38	31	56	81	63	88	25	75	75	6	38	88	56	50	16

INITIAL 500 MB. MAP TYPE 23

500 MB. MAP TYPE	XJ	YE	CT	EG	XD	RM	VG	QF	YC	QL	XH	PC	BA	JA	ET	MM	ZH	ZU	PY	OJ	QU	PE	OD	NUMBER OF CASES
OTHER	26	26	4	26	22	35	17	17	9	9	9	9	17	4	9	39	30	17	17	13	13	30	13	23

INITIAL 500 MB. MAP TYPE 24

500 MB. MAP TYPE	XJ	YE	CT	EG	XD	RM	VG	QF	YC	QL	XH	PC	BA	JA	ET	MM	ZH	ZU	PY	OJ	QU	PE	OD	NUMBER OF CASES
OTHER	31	19	50	69	56	88	44	75	75	88	88	56	81	56	69	44	69	56	31	19	56	13	38	16

INITIAL 500 MB. MAP TYPE 25

500 MB. MAP TYPE	XJ	YE	CT	EG	XD	RM	VG	QF	YC	QL	XH	PC	BA	JA	ET	MM	ZH	ZU	PY	OJ	QU	PE	OD	NUMBER OF CASES
1	23	43	14	25	23	28	22	22	20	14	8	17	20	29	32	40	42	32	51	29	23	18	29	65
2	13	31	9	16	16	16	9	9	9	0	0	6	9	16	25	38	25	22	53	28	6	13	19	32
25	14	45	17	19	19	21	17	17	10	12	5	12	10	14	29	31	31	33	40	29	24	17	21	42
OTHER	21	24	18	27	21	27	21	30	30	21	15	24	21	24	24	30	39	21	45	30	18	15	33	33

INITIAL 500 MB. MAP TYPE 26

500 MB. MAP TYPE	XJ	YE	CT	EG	XD	RM	VG	QF	YC	QL	XH	PC	BA	JA	ET	MM	ZH	ZU	PY	OJ	QU	PE	OD	NUMBER OF CASES
1	69	69	31	31	23	31	23	0	0	8	0	15	23	46	46	54	62	38	23	62	69	46	31	13
3	69	69	15	23	23	38	15	8	0	0	23	15	38	46	38	46	62	23	15	54	62	62	15	13
8	45	36	18	27	9	27	0	18	18	18	0	9	27	36	45	18	36	27	9	18	36	27	18	11
OTHER	48	43	14	10	10	24	5	14	10	10	10	19	38	43	33	43	33	43	19	38	38	48	19	21

INITIAL 500 MB. MAP TYPE 27

500 MB. MAP TYPE	XJ	YE	CT	EG	XD	RM	VG	QF	YC	QL	XH	PC	BA	JA	ET	MM	ZH	ZU	PY	OJ	QU	PE	OD	NUMBER OF CASES
OTHER	15	23	31	46	31	77	15	38	69	69	46	38	62	38	38	38	54	46	46	15	23	23	31	13

INITIAL 500 MB. MAP TYPE 28

500 MB. MAP TYPE	XJ	YE	CT	EG	XD	RM	VG	QF	YC	QL	XH	PC	BA	JA	E†	MM	ZH	ZU	PY	OJ	QU	PE	OD	NUMBER OF CASES
2	19	23	13	16	19	29	16	19	16	13	0	10	13	3	26	23	26	29	19	23	19	26	32	31
28	14	28	14	7	10	21	10	10	14	14	3	7	10	3	21	28	17	21	21	24	10	17	31	29
OTHER	24	24	8	19	14	19	16	24	22	11	8	14	14	11	22	16	14	27	19	8	16	16	30	37

INITIAL 500 MB. MAP TYPE 29

500 MB. MAP TYPE	XJ	YE	CT	EG	XD	RM	VG	QF	YC	QL	XH	PC	BA	JA	ET	MM	ZH	ZU	PY	OJ	QU	PE	OD	NUMBER OF CASES
OTHER	0	0	23	15	8	8	0	38	15	31	38	15	8	8	0	46	15	0	23	8	8	0	23	13

INITIAL 500 MB. MAP TYPE 30

500 MB. MAP TYPE	XJ	YE	CT	EG	XD	RM	VG	QF	YC	QL	XH	PC	BA	JA	ET	MM	ZH	ZU	PY	OJ	QU	PE	OD	NUMBER OF CASES
OTHER	35	27	54	31	38	50	54	50	38	42	42	19	31	35	35	35	35	46	35	35	23	27	65	26

INITIAL 500 MB. MAP TYPE 31

500 MB. MAP TYPE	XJ	YE	CT	EG	XD	RM	VG	QF	YC	QL	XH	PC	BA	JA	ET	MM	ZH	ZU	PY	OJ	QU	PE	OD	NUMBER OF CASES
OTHER	45	0	36	55	55	64	45	82	73	55	36	45	64	27	45	9	45	36	9	18	27	18	45	11

INITIAL 500 MB. MAP TYPE 32

500 MB. MAP TYPE	XJ	YE	CT	EG	XD	RM	VG	QF	YC	QL	XH	PC	BA	JA	ET	MM	ZH	ZU	PY	OJ	QU	PE	OD	NUMBER OF CASES
OTHER	33	50	83	67	56	83	39	83	56	67	39	72	78	33	72	33	44	50	50	22	39	33	39	18

INITIAL 500 MB. MAP TYPE 33

500 MB. MAP TYPE	XJ	YE	CT	EG	XD	RM	VG	QF	YC	QL	XH	PC	BA	JA	ET	MM	ZH	ZU	PY	OJ	QU	PE	OD	NUMBER OF CASES
OTHER	24	26	66	58	45	58	55	63	47	55	55	34	50	34	50	55	42	47	47	24	21	47	47	38

INITIAL 500 MB. MAP TYPE 34

500 MB. MAP TYPE	XJ	YE	CT	EG	XD	RM	VG	QF	YC	QL	XH	PC	BA	JA	ET	MM	ZH	ZU	PY	OJ	QU	PE	OD	NUMBER OF CASES
OTHER	20	60	60	20	20	80	20	60	20	100	80	100	60	40	20	20	80	80	20	20	20	0	60	5

INITIAL 500 MB. MAP TYPE 35

500 MB. MAP TYPE	XJ	YE	CT	EG	XD	RM	VG	QF	YC	QL	XH	PC	BA	JA	ET	MM	ZH	ZU	PY	OJ	QU	PE	OD	NUMBER OF CASES
OTHER	56	28	52	68	76	64	48	48	56	24	12	44	68	48	88	40	56	80	36	44	56	60	28	25

INITIAL 500 MB. MAP TYPE U

500 MB. MAP TYPE	XJ	YE	CT	EG	XD	RM	VG	QF	YC	QL	XH	PC	BA	JA	ET	MM	ZH	ZU	PY	OJ	QU	PE	OD	NUMBER OF CASES
U	38	30	39	34	33	50	27	46	49	55	39	60	56	41	46	18	20	35	14	19	33	19	19	100
OTHER	31	34	34	34	37	47	26	41	41	46	35	54	44	44	44	24	37	31	28	21	32	31	31	68

APPENDIX 9

SUMMER 500 MB. MAP TYPE PoPs ($\geq$ 0.10 INCHES)

Twenty-four hour percent probabilities of precipitation ($\geq$ 0.10 inches) are listed for each 500 mb. map type. The number of cases used to calculate the probabilities are indicated for each map type.

The station locations are shown in Figure 5 (page 52).

500 MB. MAP TYPE	XJ	YE	CT	EG	XD	RM	VG	QF	YC	QL	XH	PC	BA	JA	ET	MM	ZH	ZU	PY	OJ	QU	PE	OD	NUMBER OF CASES
1	19	22	8	18	19	20	18	18	12	5	5	6	16	17	21	24	22	20	23	22	15	15	20	422
2	8	9	5	7	9	9	7	6	4	3	3	3	4	7	10	14	9	9	13	11	4	7	11	276
3	35	30	12	25	27	31	27	29	18	11	12	11	27	23	33	31	37	35	23	27	28	31	29	201
4	11	15	20	22	20	28	22	20	26	21	16	21	21	13	24	26	22	16	15	15	15	18	21	89
5	10	16	16	12	16	22	21	19	26	18	21	18	15	13	16	22	16	18	15	13	13	7	22	68
6	4	6	6	6	4	13	4	10	8	13	4	15	12	6	12	23	6	12	15	0	4	2	13	52
7	46	34	32	46	41	49	46	44	32	20	17	22	34	44	49	29	49	49	22	24	51	46	41	41
8	10	20	4	9	9	8	7	6	7	2	3	2	5	14	14	16	16	15	10	13	14	10	11	175
9	15	15	23	31	31	46	31	31	38	46	23	46	46	23	54	31	38	46	15	8	31	23	23	13
10	5	0	0	0	0	11	0	11	21	21	11	21	16	11	11	0	0	5	0	0	5	0	0	19
11	17	22	15	19	12	18	17	18	5	6	9	6	9	17	17	26	14	17	20	20	12	14	16	103
12	35	12	15	42	46	50	35	46	35	19	15	23	35	23	50	8	38	42	8	15	38	23	19	26
13	0	9	18	18	27	36	36	45	64	36	45	55	55	18	36	18	18	9	0	9	9	9	45	11
14	7	5	14	21	21	16	12	19	7	19	14	23	12	9	21	26	23	12	30	7	9	14	19	43
15	37	20	29	39	41	39	51	31	31	31	15	19	27	15	31	44	42	29	34	22	37	24	46	59
16	7	11	2	5	2	5	5	5	0	5	5	5	0	5	5	14	0	7	11	7	2	5	2	44
17	5	10	5	25	5	15	10	10	15	20	10	30	30	15	20	20	30	5	5	5	10	5	40	20
18	19	15	7	19	15	15	11	15	11	11	4	4	19	22	19	11	15	11	7	22	19	4	7	27

500 MB. MAP TYPE	XJ	YE	CT	EG	XD	RM	VG	QF	YC	QL	XH	PC	BA	JA	ET	MM	ZH	ZU	PY	OJ	QU	PE	OD	NUMBER OF CASES
19	11	17	9	13	15	24	6	19	17	11	17	15	17	15	26	13	15	22	4	11	15	11	11	54
20	0	0	0	0	0	0	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12
21	6	6	56	31	25	56	50	44	69	44	44	38	50	13	38	19	0	13	31	19	13	6	50	16
22	50	33	0	17	22	44	11	11	28	17	17	28	39	33	72	17	78	61	6	17	56	44	17	18
23	20	7	0	20	7	7	0	13	7	7	7	7	13	0	0	13	7	0	7	7	7	27	0	15
24	9	9	27	36	36	82	36	45	36	64	36	45	27	36	55	45	55	36	27	9	45	18	27	11
25	6	8	8	5	6	12	9	9	9	5	5	6	8	3	13	17	12	11	25	15	4	4	15	93
26	24	39	6	9	12	9	6	9	6	6	3	3	12	21	27	21	30	18	6	18	24	21	12	33
27	13	13	25	13	0	38	0	25	63	25	25	13	25	25	25	38	38	25	25	13	25	25	38	8
28	15	11	4	4	7	11	7	5	9	9	4	9	9	2	7	11	9	15	5	7	4	7	13	55
29	0	0	10	10	0	0	0	0	0	20	10	10	0	0	0	10	0	0	10	0	0	0	10	10
30	20	0	33	20	20	40	27	20	7	27	33	20	20	20	20	27	7	33	27	7	7	7	40	15
31	29	0	29	29	43	57	29	14	57	14	29	29	29	14	29	14	14	14	14	14	29	14	14	7
32	9	0	27	36	0	64	9	36	27	45	27	45	36	18	27	18	36	9	0	9	0	0	9	11
33	5	0	29	24	24	33	33	33	33	33	33	19	29	10	29	14	14	24	14	10	5	19	24	21
34	0	25	50	25	25	50	25	25	25	50	25	25	25	0	25	0	0	50	0	0	0	0	0	4
35	47	13	27	60	53	53	47	27	33	7	0	13	27	33	53	33	47	53	20	27	53	27	20	15
U	21	12	21	23	23	36	19	31	31	34	23	42	35	23	33	10	16	23	9	7	19	11	14	159

APPENDIX 10

SUMMER SURFACE MAP TYPE PoPs ($\geq$ 0.10 INCHES)

Twenty-four hour percent probabilities of precipitation ($\geq$ 0.10 inches) are listed for each surface map type. The number of cases used to calculate the probabilities are indicated for each map type.

The station locations are shown in Figure 5 (page 52).

SURFACE MAP TYPE	XJ	YE	CT	EG	XD	RM	VG	QF	YC	QL	XH	PC	BA	JA	ET	MM	ZH	ZU	PY	OJ	QU	PE	OD	NUMBER OF CASES
1	22	13	26	26	20	48	26	46	46	46	24	52	30	15	48	4	15	35	0	7	28	11	26	46
2	8	16	6	13	10	10	10	13	7	4	4	1	7	12	12	20	10	11	21	19	7	11	14	210
3	8	13	0	6	2	2	2	2	2	0	0	2	4	13	4	15	2	11	9	17	6	8	2	53
4	23	16	20	30	26	29	33	27	23	15	16	8	21	17	27	36	26	23	28	23	16	19	30	192
5	11	5	8	5	8	8	3	11	8	5	5	11	8	3	3	5	8	5	0	5	8	8	5	37
6	33	10	39	47	41	71	35	57	51	45	33	57	59	37	53	22	31	47	16	8	35	14	35	49
7	6	4	2	8	6	2	8	8	0	2	0	2	4	2	8	22	16	6	29	10	6	14	16	49
8	20	0	0	0	0	0	0	0	0	0	10	10	0	10	10	0	0	0	0	0	10	0	0	10
9	14	26	6	13	12	12	13	11	5	5	6	3	6	14	16	27	19	19	25	23	8	14	13	108
10	16	16	32	20	24	36	16	40	36	36	28	44	28	12	24	8	24	28	0	0	28	8	16	25
11	30	10	0	0	10	10	10	20	0	10	0	0	10	10	10	10	10	20	10	20	0	10	10	10
12	10	20	0	0	2	0	2	0	2	0	2	0	5	7	7	7	7	7	7	12	7	5	2	41
13	11	8	5	8	11	19	9	19	19	6	8	8	11	5	14	14	14	8	31	13	8	14	11	64
14	41	29	56	59	54	80	46	71	56	29	29	46	56	51	63	32	44	59	17	22	49	24	46	41
15	25	8	0	0	0	0	8	0	0	0	0	0	0	25	0	0	0	0	8	8	0	8	0	12
16	33	0	0	17	17	50	17	33	0	33	17	33	33	17	33	0	0	17	33	0	17	0	0	6
17	1	6	1	7	4	0	1	3	0	0	0	0	4	10	3	10	6	1	8	3	1	1	0	71
18	0	0	0	50	50	0	0	0	0	0	0	0	0	0	50	0	0	50	0	0	0	0	0	2

SURFACE MAP TYPE	XJ	YE	CT	EG	XD	RM	VG	QF	YC	QL	XH	PC	BA	JA	ET	MM	ZH	ZU	PY	OJ	QU	PE	OD	NUMBER OF CASES
19	31	11	23	34	34	57	26	49	49	57	29	69	49	29	49	11	23	40	0	0	34	14	26	35
20	41	18	45	50	50	55	50	41	59	50	36	55	59	32	64	27	45	59	9	9	55	32	50	22
21	20	80	0	0	0	0	0	0	0	0	0	0	0	20	0	0	20	20	0	40	20	20	0	5
22	0	100	0	100	0	100	100	0	0	0	0	0	100	0	0	100	100	0	100	0	0	100	0	1
23	69	63	31	25	31	44	25	44	38	31	6	25	31	44	75	25	38	63	6	19	63	63	13	16
24	63	50	25	38	38	50	25	13	25	13	0	25	50	50	75	25	38	75	25	25	63	50	25	8
25	21	37	16	32	37	47	53	32	37	21	26	32	32	42	47	16	21	37	16	11	11	11	53	19
26	4	4	4	15	23	4	0	4	4	4	4	8	4	0	4	12	4	4	15	0	4	4	4	26
27	8	3	5	3	5	3	3	5	8	11	5	16	11	3	5	0	5	5	0	5	5	3	0	37
28	8	17	6	2	4	4	4	0	6	10	4	0	4	8	8	19	6	8	15	19	6	13	10	48
29	0	0	0	0	0	0	0	20	0	0	0	0	20	0	0	0	0	0	0	0	0	0	0	5
30	6	0	22	28	28	50	22	33	22	56	22	56	33	11	28	11	28	17	6	0	11	6	17	18
31	75	63	0	50	50	13	25	25	0	0	13	0	13	13	25	63	50	38	38	50	38	50	13	8
32	44	25	13	38	19	44	19	38	31	31	19	44	50	31	56	13	44	44	13	0	44	31	13	16
33	11	33	0	0	0	0	0	0	0	0	0	0	11	33	0	22	22	22	22	44	22	22	11	9
U	14	15	11	16	18	23	17	16	15	15	13	17	19	14	22	19	22	18	14	13	17	14	19	492

APPENDIX 11

THE BRIER SCORE

One essential criterion for a successful verification method is that improving the average score is consistent with a better forecast of the specific situation. If this is not done, on occasion, it will turn out that the "best" forecast on the basis of score is not the most useful forecast. The Brier Score meets the above criterion and is explained in an article by Brier and Allen (1951).

For a single forecast, the Brier Score can be written:

$$B = (F - E)^2 \qquad (11\text{-}1)$$

where F equals the forecast probability of occurrence which ranges from zero to one and E equals zero if the event does not occur or, one if the event occurs. The value of B range from zero to one with zero, the best score.

The Brier Score becomes more meaningful when averaged over a large number of forecasts.

Let N = number of forecasts

F_i = forecast probability on the i^{th} forecast

E_i = 1 if event occurs on the i^{th} occasion

= 0 if non-occurrence on the i^{th} occasion.

The Brier Score for the N forecasts (B_n) is:

$$B_n = \frac{1}{N}\sum_{i=1}^{N} [F_i - E_i]^2 \qquad (11\text{-}2)$$

Suppose now that all probabilities F_i are expressed in tenths and that the set of N forecasts are classified into subsets according to the value of F_i, the forecast probabilities. There will then be eleven subsets as follows:

$$F_i = 0.0,\ 0.1,\ 0.2,\ .\ .\ .0.9,\ 1.0$$

to be designated by k where

$$k = 1, 2, 3, \ .\ .\ .\ 11.$$

Consider a subset "k" which is made up of M_k forecasts (e.g., if 0.6 chance of rain was forecast on fifteen occasions then $M_7 = 15$) and a total of R_k event occurrences (e.g., if rain occurred in the fifteen forecasts ten times, $R_7 = 10$). The a posteriori, or empirical probability will be

$$\emptyset_k = \frac{R_k}{M_k} \qquad (11\text{-}3)$$

for the example,

$$\emptyset_7 = 10/15 = 0.67.$$

From equation 11-2, the contribution to the Brier Score for the event occurrences is $1/M_k \ (F_k - 1)^2 \ R_k$ and the contribution for the days for the non-occurrences is $1/M_k \ (F_k - 0)^2 \ (M_k - R_k)$. The Brier Score for the k^{th} subset is then given by

$$B_k = (F_k - 1)^2 \emptyset_k + F_k^2 (1 - \emptyset_k) \qquad (11\text{-}4)$$

The mean Brier Score, considering all subsets, will be

$$B = \frac{1}{N} \sum_{k=1}^{11} M_k B_k \qquad (11\text{-}5)$$

where $N = \sum_{k=1}^{11} M_k$.

Equation 11-4 may be simplified by adding and subtracting $\emptyset_k^2$ and rearranging terms to obtain

$$B_k = (F_k - \emptyset_k)^2 + \emptyset_k (1 - \emptyset_k) \qquad (11\text{-}6)$$

with the mean Brier Score becoming

$$B = \frac{1}{N} \sum_k M_k \left\{ (F_k - \emptyset_k)^2 + \emptyset_k (1 - \emptyset_k) \right\} \qquad (11\text{-}7)$$

The quantity $(F_k - \emptyset_k)^2$ measures how close to the actual frequency $\emptyset_k$, the group of forecasts with probability F_k predicted the event to occur. Sanders (1963) calls this term a measure of the "validity" of the forecasts, while other authors, e.g., Root (1962), refer to it as the "reliability." To minimize the reliability term, the forecast probability F_k should equal the relative frequency $\emptyset_k$.

This term usually turns out to be rather small. It is the second term of equation 11-6 which is the main contributor to the Brier Score.

The quantity $\emptyset_k (1 - \emptyset_k)$ is a measure of the "sharpness" (Sanders, 1963) or "resolution" (Root, 1962) of the forecasts. To demonstrate this term, suppose that the forecaster has been able to assess his probabilities so that F_k always equals $\emptyset_k$, i.e., perfect reliability. The Brier Score then becomes

$$B_k = \emptyset_k (1 - \emptyset_k)$$

and this term reaches its minimum, zero, only when

$$\emptyset_k = 0 \quad \text{or} \quad \emptyset_k = 1 ,$$

that is, when all M_k instances have been sorted into two categories, in one which the event occurs and in the other of which the event does not occur.

The term reaches its maximum value, 0.25, when $Ø_k = 0.5$.

Remembering the assumption that the forecaster is able to make $F_k = Ø_k$, it is thus seen that to minimize the resolution term, the forecast probability should be as close as possible to the extreme ends of the probability scale.

The reliability of forecasts is illustrated in Figure 8, by plotting, for each probability interval, the forecast probability against the observed rain occurrence. Included in the graph is the number of forecasts issued in each probability category.

Since the diagonal line represents perfect reliability, (observed frequency = forecast probability), the vertical distance between the diagonal and the plotted line $(F_k - Ø_k)$ indicates the amount of error in the respective probability forecast. Since $(F_k - Ø_k)^2$ is the squared deviation, it is, therefore, a measure of the reliability of the forecasts in the k^{th} subset.

The root-mean-square error (RMSE) in reliability for all probability categories can therefore be defined as

$$\text{RMSE} = \left\{100/N\right\} \sum_k M_k (F_k - Ø_k)^2 \qquad (11\text{-}8)$$

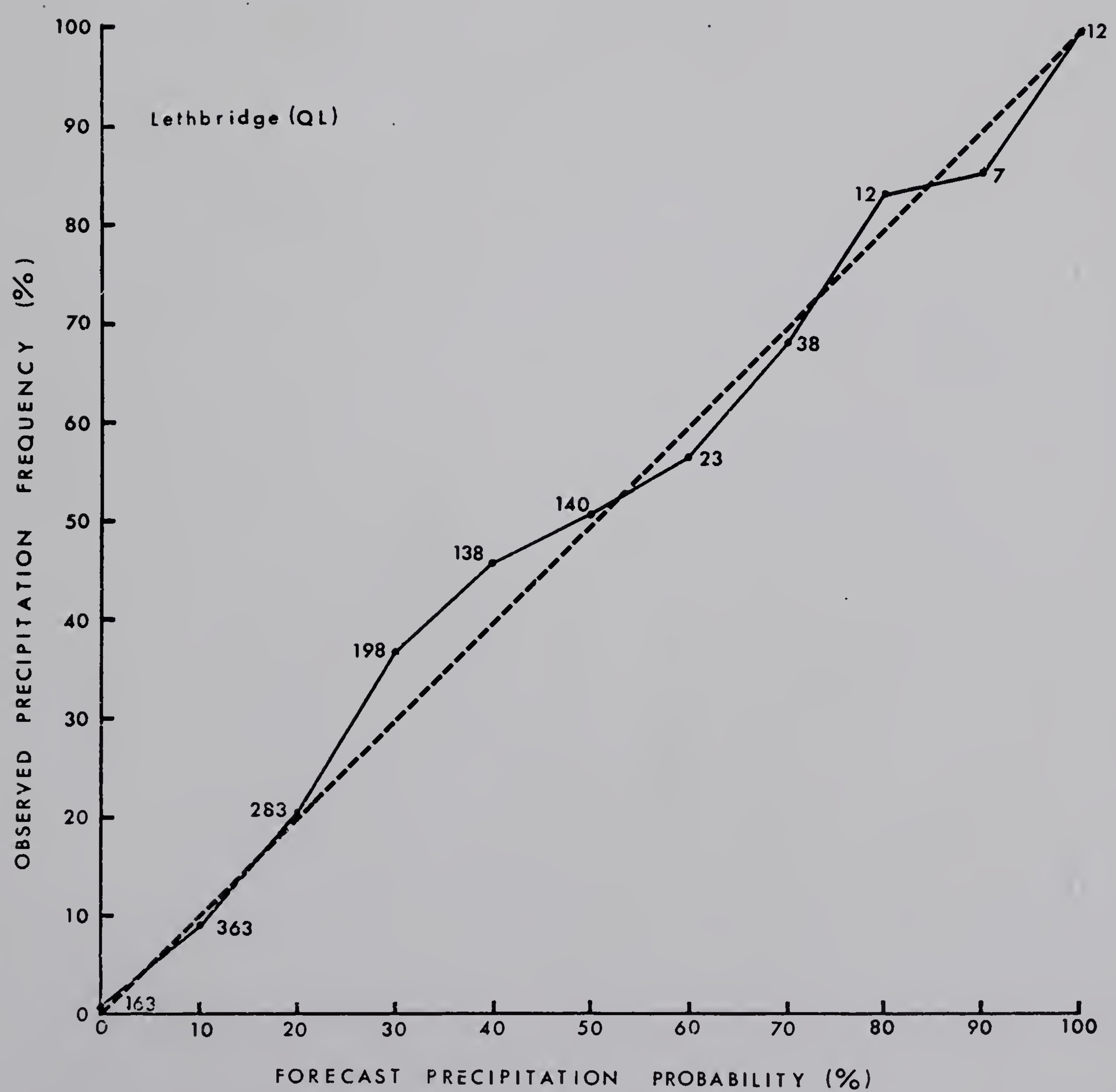
If there is a major difference in the climatic frequency of particular weather phenomena between one locality and another, the respective Brier Scores will not be comparable. In an attempt to overcome this, a skill score can be defined as

$$S = 100\ (1 - B/cB) \qquad (11\text{-}9)$$

where cB is the Brier Score obtained by employing the climatological frequency as the forecast probability, and B equals the Brier Score obtained by using the forecast probabilities.

FIGURE 8

Verification of Precipitation Probability Forecasts Using Primary 500 mb. and Surface Map Types (May - September, 1963-1971, 06Z-06Z)



The climatological Brier Score is defined by

$$cB = c^2 - 2cR/N + R/N \tag{11-10}$$

where c is the climatic frequency, R is the total number of event occurrences and N is the total number of forecasts.

The skill score, thus defined, provides a measure of the percentage improvement of the forecast probabilities over the use of the climatological frequency as the probability forecast.